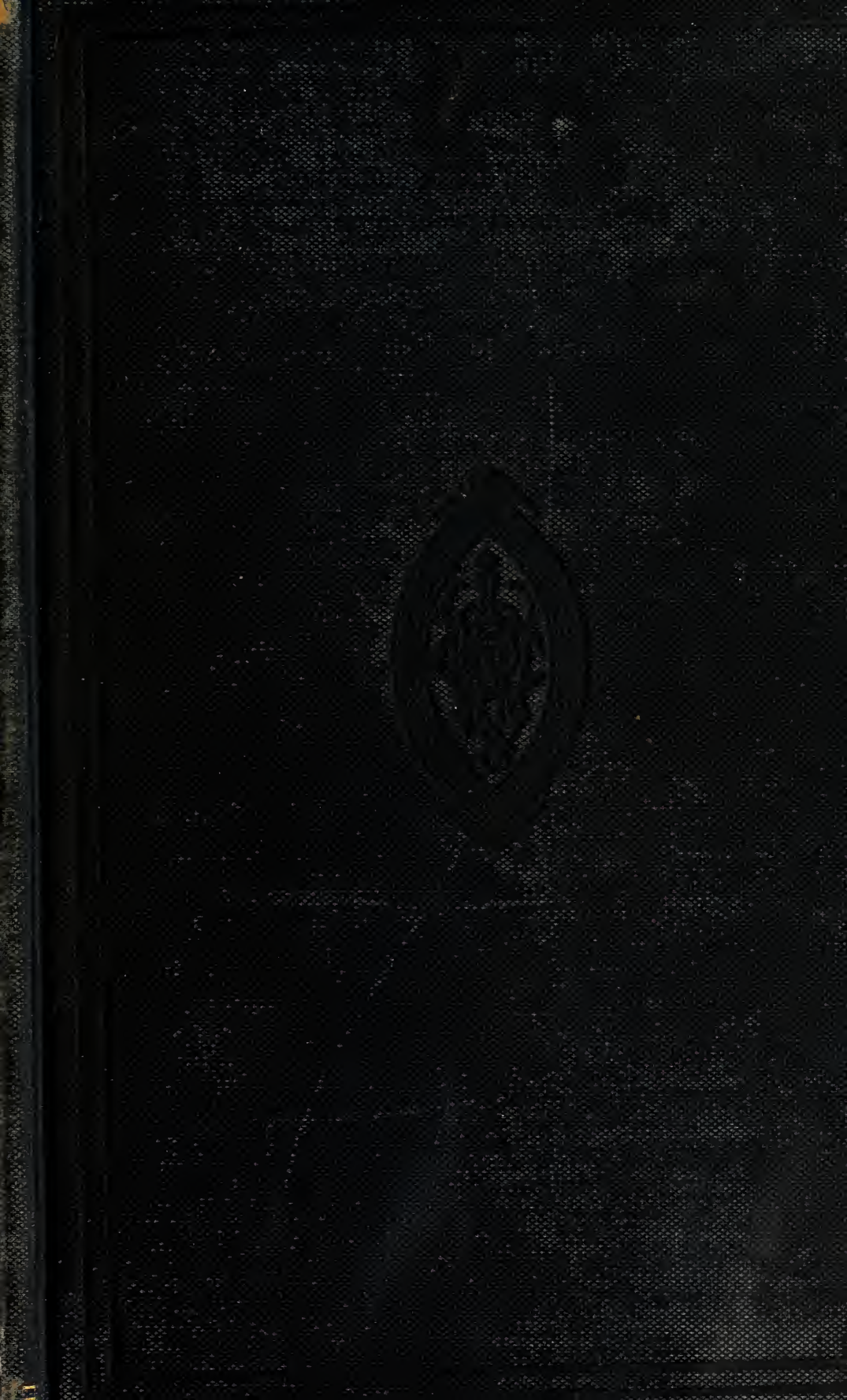

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TREATISE

ON

ORTHOPEDIC SURGERY

BY

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THIRD EDITION

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NEW YORK

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Charles William Eliot

PRESIDENT OF HARVARD UNIVERSITY, THIS BOOK IS DEDICATED. AN EXPRESSION OF RESPECT FOR THE MOST STIMULATING OF EDUCATORS.

PREFACE TO THE THIRD EDITION.

In preparing the third edition of this work it has been necessary to rewrite entirely several portions, to make extensive alterations in others, and to rearrange chapters and subjects. These changes have been made in the endeavor to offer to the reader a description of the present condition of orthopedic surgery with its notable progress since the publication of the second edition in 1899.

The most marked difference between the second and third editions will be found in the chapters treating of congenital dislocation of the hip, of scoliosis, of traumatic and non-traumatic coxa vara, and of non-tuberculous diseases of the joints, as it is in the study of these subjects that the greatest advances have been made. Many original illustrations have been added and many of the old ones have been improved, making them more illustrative of the subjects mentioned in the text.

A chapter giving the details of orthopedic apparatus, with descriptions and drawings of appliances found to be of practical efficiency, is added in the hope of giving to the general practitioner technical information which is of use in the treatment of orthopedic affections.

The authors are greatly indebted to friends and colleagues for many helpful suggestions and for their ready permission to make use of their illustrations and clinical material.

Boston, April 1st, 1905.

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ORTHOPEDIC SURGERY.

CHAPTER I.

TUBERCULOUS DISEASE OF THE JOINTS.

Pathology.—Etiology.—Prognosis.—Principles of Treatment.

Orthopedic surgery deals with the prevention and correction of deformity, and demands not only a study of the deformities of the human body, but also some knowledge of the affections which produce them. Of these the most important are the tuberculous diseases of the joints.

Bone tuberculosis has been called strumous, scrofulous, and fungus disease, caries of bone, etc., and various theories as to the predisposing cause have been presented. It is known to be the result of the invasion of the tubercle bacillus, which frequently finds a favorable soil for development in the spongy bone of the growing epiphyses.

PATHOLOGY.

Articular tuberculosis begins as an affection of the spongy tissue of the epiphysis, generally near its line of junction with the shaft, occasionally near the articular cartilage. It occurs usually as a localized disease, appearing in one or more distinct foci; a simultaneous tuberculous infiltration of the whole epiphysis, however, rarely happens.

The common form of tuberculous infection of the epiphysis is the one spoken of as focal or encysted, when the first change is the formation of single or multiple foci of tuberculous degeneration. On section of the diseased epiphysis the first noticeable change consists in a local hyperæmia of some part of the spongy tissue. There then appears in this hyperæmic area a small, grayish, translucent spot, almost as small as one can see, which grows more gray and increases in size, while a zone of hyperæmic tissue develops around it and the neighboring bone looks boggy from an excess of the transuded fluid. At first usually there is no synovitis; it is purely a localized ostitis.

The tubercle bacilli, being lodged in the marrow of the bone, cause a multiplication of the surrounding cells, probably by the action of a toxin, and a typical tubercle is formed. Such an area consists of a central mass of giant and epithelioid cells surrounded by a zone of lym-

phoid cells. As the tuberculous area increases by multiplication of the cells, the centre degenerates, forming a necrotic mass in which fat drops may be seen. Sometimes the tubercle bacillus can be found, usually in small numbers, in the giant cells, or in the epithelioid cells, or between them. The process extends by the formation of other tubercles, apparently due to the multiplication of the tubercle bacilli and their diffusion through the tissues. New necrotic areas like the first are found, which coalesce and form a mass of caseous material. Around the tuberculous area there appears a zone of non-tuberculous granulation tissue early in the process. During the later and reparative stages of the process this area becomes less vascular and is converted into denser fibrous tissue.

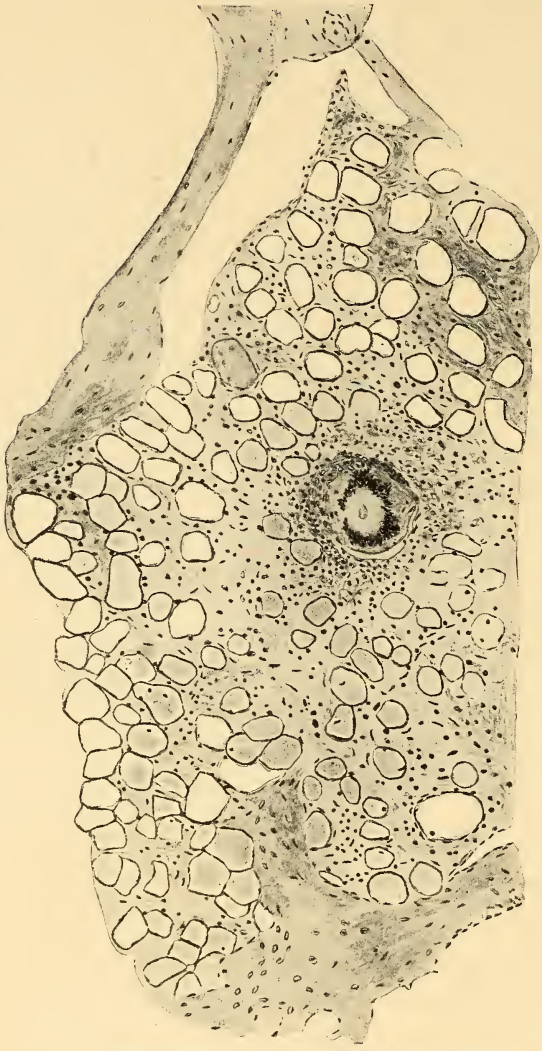


FIG. 1.—Section of Tuberculous Synovial Membrane. (Nichols.)

As the individual tubercles meet and coalesce, they form, in the marrow of the bone, irregular caseous masses. In this way large areas of bone may be involved by peripheral enlargement of the tuberculous area. This area may soften and a tuberculous bone abscess may result, the purulent material containing bone fragments like sand.

Instead of forming a "bone abscess" the process may result in the formation of a sequestrum composed of necrotic trabeculæ retaining their shape and lying in a cavity in the bone. About the sequestrum is a layer of granulation tissue. The sequestrum may take the shape

of a wedge having its base toward the joint, in which case it is known as a "bone infarct."

As the diseased focus grows larger it looks more yellow in spots, and shows at its centre a tendency to cheesy degeneration, and later in the history of the affection one finds nodules, varying in size from that of a pea to a hazelnut, which are filled with a putty-like substance, such as the cheesy material found elsewhere in the body, except that it contains spicules of bone from the trabeculæ, and in the larger foci pieces of dead bone of considerable size are found.

Later in the history of the affection the tuberculous nodule may break down into purulent material.

Generally the original focus is surrounded by smaller tubercles, which aid in its extension; but the chief work is done by the erosive action of the granulations, which take the place of the progressively rarefied bone.

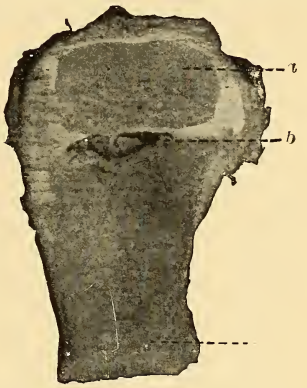


FIG. 2.—Tumor Albus. Small focus in upper epiphyseal line of tibia. Synovitis of joint, but no tuberculous process apart from focus as noted. Death from miliary tuberculosis. *a*, Epiphysis; *b*, primary focus; *c*, shaft. (Nichols.)

From the stage of tuberculous infiltration the process may follow any one of three courses: the diseased focus may be absorbed and so

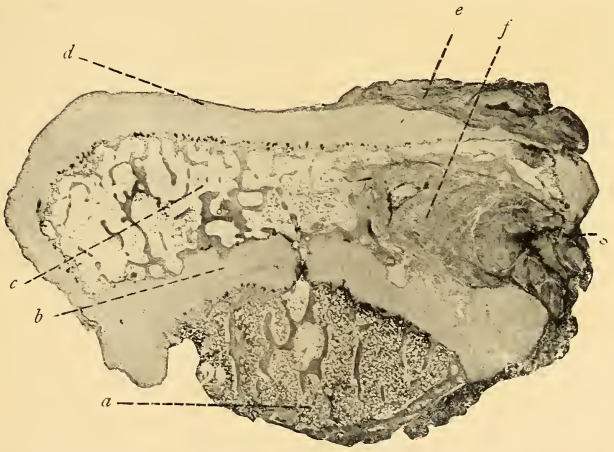


FIG. 3.—Tuberculous Epiphysis. Vertical section through the head of the radius. *a*, Shaft of radius; *b*, epiphyseal cartilage; *c*, epiphysis; *d*, joint surface; cartilage; *e*, tuberculous primary focus; *f*, perforation of joint cartilage and infection of joint; *g*, tuberculous "pannus" extending over joint cartilage. (Nichols.)

cured; it may extend to the periphery of the bone and break through the periosteum and empty itself there; or, lastly and probably most commonly, it may extend to the joint and infect that.

1. The absorption of the diseased focus is theoretically possible up to a late stage in the process, so long as the disease remains strictly local and no sequestra of any size have formed; the pus may become cheesy and calcified.

2. The next most favorable termination to the disease is when the focus does not infect the joint, but breaks through the periosteum and discharges into the periarticular structure. This happens when the focus is so situated that the line of least resistance takes it to another part of the bony surface away from the joint, there forming probably an abscess which must be evacuated externally or break. Sometimes this ends the disease; the granulation tissue becomes fibrous, and then osseous, and the disease is over. This, according to Krause, is most likely when the focus is in the upper or lower end of the tibia or in the olecranon.[1] It is not likely to occur in the hip on account of the extensive distribution of the capsule.

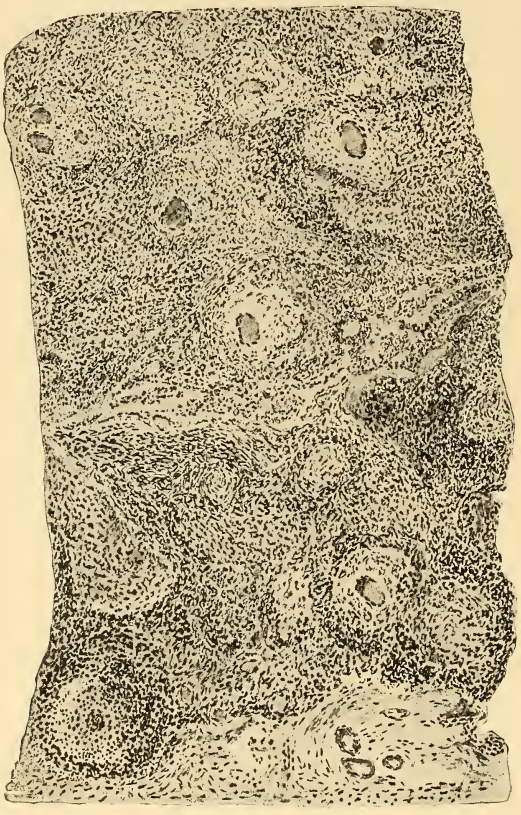


FIG. 4.—Section of Tuberculous Synovial Membrane. Numerous tubercles with giant cells. Between these, œdematous granulation tissue with many lymphoid and plasma cells. (Nichols.)

3. Probably the commonest course for this localized ostitis to pursue is to break into the joint cavity, and the ease with which infection of the joint from the epiphysis is produced will be readily understood by considering the pathological conditions.

The seat of the disease in the beginning is ordinarily not far from the cartilage. At first it excites no joint inflammation, but when it reaches a certain stage, even before it breaks into the joint, inflammatory reaction in the joint begins.[2] The inflammation of the joint at

[1] Krause: "Tub. der K. und Gelenke," 1891.

[2] Lannelongue: "Coxo-tuberculose," Paris, 1886.

first is non-tuberculous, the synovial membrane appearing thick and œdematous, the cavity of the joint being filled with a serous inflammatory exudate. This process may be very extensive.

Perforation of the joint by the tuberculous focus is the next step in the process. When the tuberculous focus underlies it, the cartilage of the joint begins to disintegrate and appears softened and yellow, and

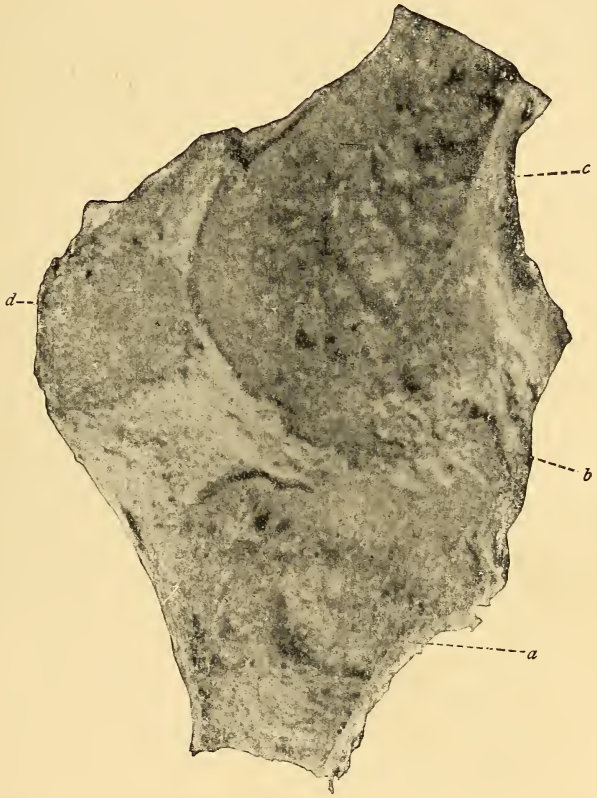


FIG. 5.—Tuberculous Knee, Process of Repair Advanced. Small focus persists. *a*, Tibia; *b*, tuberculous softening; *c*, femur; *d*, patella. (Nichols.)

finally breaks through. The perforation frequently occurs near ligaments. The tubercle bacilli, having entered the joint, are quickly disseminated by movement of the articulation, and the synovial membrane becomes infected.

The synovial membrane then appears thick, smooth, and shining, and sometimes nodular; the surface is studded with small specks not larger than the head of a pin. The yellow tuberculous areas increase and soften, and tuberculous ulcers of the synovial membrane form. The thickened synovial membrane extends as a pannus growth over the

edge of the articular cartilage, sometimes covering the whole cartilage. At the same time the tuberculous process may extend between the cartilage and bone. The cartilage beneath the pannus layer is destroyed and disintegrated, while the free surface of the cartilage becomes fibrillated and ulcers appear in it also. When the tuberculous process extends beneath the cartilage the latter is eroded and destroyed.

Large areas of cartilage may be detached from the underlying bone, and sometimes the entire cartilage may be loosened, as in the hip-joint. Under these conditions the denuded end of the bone is seen to be covered with nodular granulation tissue filled with tubercles, caseous and otherwise. As the disease goes on the cartilage is destroyed or cast off in flakes, and the denuded bones are attacked by the tuberculous process and are eroded. As a result of this, articular cavities are enlarged and distorted, and distortions and subluxations may occur. The tonic muscular contraction accompanying joint disease tends in certain joints to crowd together the softened ends of the bones and hasten the wearing away.

Microscopical examination of the diseased area at any time before all structure is lost shows a typical granulating tuberculosis.

Thickening of the capsule, infiltration of the periarticular tissues, and thickening of the ends of the bones are clinical manifestations, and abscess formation and all the other complications are ready to follow.

About the affected joint is formed a layer of granulation tissue which may be converted into fibrous tissue. This process may be very extensive and accounts for such phenomena as the ovoid swelling in tumor albus and the thickening of the trochanter in hip disease. This fibrous tissue may be œdematous, and the spaces may contain a fluid reacting to stains like mucin.

Repair is brought about by the formation of fibrous tissue, probably arising from the layer of non-tuberculous granulation tissue which grows into and replaces the tuberculous material. Caseous material is largely absorbed, and the inspissated remainder is replaced by fibrous tissue or is calcified and encapsulated. Fibrous, cartilaginous, or bony ankylosis may result from the process of repair.

It is most important to note that the process of repair may be incomplete, and that small areas of tuberculous material encapsulated by fibrous tissue may persist for a long time and under favorable conditions may become active and cause a recurrence of the disease. This fact must always be borne in mind in forcibly manipulating convalescent tuberculous joints. Or the repair may be complete and the previously inflamed tissue be converted into cicatricial bone—usually more firm than the original structure.

Certain variations of this process must be described as other types of synovial affection from that described are found at times.

Arborescent tuberculous synovitis is the name given to a condition in which the synovial membrane is covered with branching arborescent tags frequently coated with fibrin. Sometimes a large amount of fatty tissue may be present, constituting the "lipoma arborescens."

Solitary tuberculous nodules of the synovial membrane are described. Nodular and even polypoid growths with little tendency to caseation

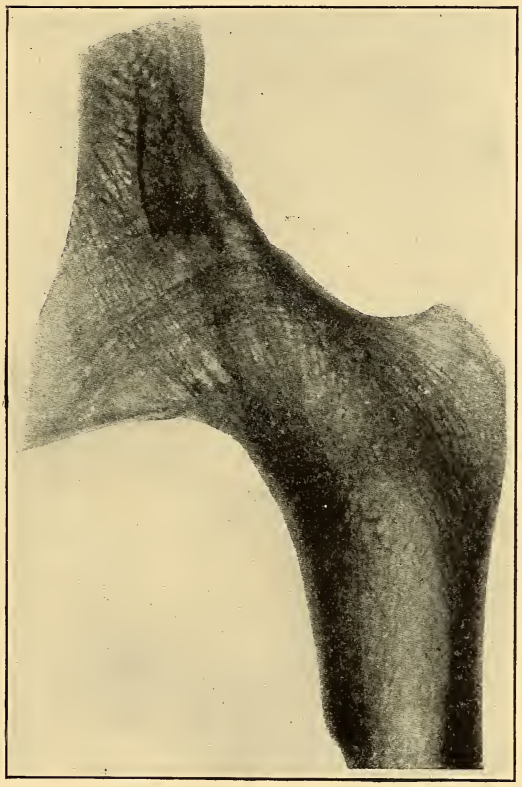


FIG. 6.—True Ankylosis of the Hip Joint. (Joachimsthal.)

project into the joint. Although at first the rest of the synovial membrane is but little affected, it becomes involved later.

Hydrops articulorum tuberculosus was a name given by König to a chronic effusion of joints said to be primarily synovial. In these there is said to be at first no marked thickening of the synovial membrane. Later the membrane assumes the typical character of tuberculous synovial inflammation. A similar condition of joints with a purulent effusion is described as "empyema tuberculosum."

It has always been asserted by writers on bone tuberculosis that primary disease of the synovial membrane occurred. Volkmann, how-

ever, as early as the writing of his classical monograph, said: "The fungous inflammations of the joints begin generally, and in children almost without exception, not at all as an arthropathy, but as a pure osteopathy, with a very circumscribed caseous or tuberculous ostitis." [1]

Nichols,[2] in one hundred and twenty tuberculous joints examined from children and adults, many from excisions, a considerable number from autopsies or amputations, did not see a joint in which, if all the bones entering into the joint were sawed open, one or more old bone foci were not found. Complete examination of a joint at operation is usually difficult and oftenest impossible, so that conclusions as to the absence of primary bone disease based upon such examinations must be accepted with caution.

Although primary tuberculosis of the synovial membrane is described by those whose statements carry great weight, the results of Nichols' investigations must be borne in mind, which are positive and not negative conclusions. And it may be assumed for clinical purposes, until the contrary is proved, that practically all tuberculous joint disease has its origin in bone.

Cold Abscesses of Joints.—If the tuberculous process in the bone reaches the surrounding tissues by perforation of the cortex and periosteum or by rupture of the joint capsule, an abscess is likely to occur. The area of tuberculous softening in the periarticular tissues is formed by the coalescence and caseation of tubercles. Surrounding the softened area is a layer of tuberculous tissue, about which is another layer of œdematous and vascular granulation tissue. This process may extend until a large cavity has been formed.

The contents of these abscesses are composed of caseous material from the degeneration of the tubercles and exuded serum with necrotic pieces of bone. In the fluid are polymorphonuclear leucocytes, often taking up little or no stain on cover slips. Pyogenic organisms are absent unless present by secondary infection. The fluid may be like true pus; it may be so thick that it will hardly flow; it may be thin and watery and contain coagula, or it may be red or brownish from hemorrhage.

Microscopically tubercle bacilli may be found in the abscess, but they are to be identified, even after prolonged search, in only about one-third of the cases. In such cases inoculation experiments must be relied upon to establish their presence.

The wall of these abscess cavities is composed of an inner layer of tuberculous tissue, outside of which is a layer of secondary inflammatory tissue. The inner layer may be granular or necrotic and ulcerated. The abscess extends by peripheral enlargement in the line of least re-

[1] Volkmann: Klin. Vortr., v., p. 1405.
[2] Nichols: Orth. Trans., vol. xi., p. 383.

sistance. The walls of tuberculous sinuses consist of an inner layer of tuberculous tissue, outside of which is a zone of œdematous granulation tissue.

Tubercle bacilli in the tissues are frequently found, though not invariably, as in the process of decalcification necessary to cut sections of bone for microscopic examination they may become so disorganized as to stain with difficulty or not to stain at all.

Inoculation of animals with tissue from bones and joints affected by this type of disease produces general tuberculosis,[1] and the disease may be experimentally produced in animals.[2]

General miliary tuberculosis of bone occurs in connection with general miliary tuberculosis. The marrow is studded with miliary tubercles; necrosis and inflammatory reaction are slight or are absent.[3]

ETIOLOGY.

Heredity.—That heredity is a factor in causing tuberculous joint disease has long been claimed. Whether the tuberculous virus can be directly transmitted as such from father or mother to the offspring must still be held open to question,[4] but that the surroundings of certain families weaken the resistance and favor tuberculous invasion appears not improbable.

Figures which attempt to show what proportion of children with joint disease inherit a tendency to these diseases are notoriously untrustworthy. In the class of hospital patients from whom most of these statistics come, anything approaching accurate information with regard to the diseases of which relatives have died cannot be expected. There is also an inclination on the part of parents to deny the existence of tuberculous disease in their parents and relatives. In this way parents of all classes are much more anxious to establish some traumatic cause for the affection of the joint than to have it supposed that the child inherited any constitutional taint. Again, it must be remembered that in a community in which approximately ten per cent of all deaths are from phthisis, phthisis must necessarily appear in the family histories of a certain proportion of any group of individuals whose antecedents are inquired into. For these reasons the statistics cannot be

[1] Cheyne: British Med. Jour., April, 1891.

[2] Deutsch. Zeit. f. Ch., 1872, xi., 317.—Schüller: "Exp. und histol. Untersuchungen." Stuttgart, 1880.—Cent. f. Ch., 1886, No. 14.

[3] König: Archiv f. klin. Chir., 26, p. 822.—Caumont: Deutsch. Zeit. f. Chir., xx., 137.—Krause: Deutsch. Chir., Lief. 28a.—Deutsch. med. Woch., 1886, 9-13.—Cent. f. Chir., 1887, p. 52.—Quoted by Barber: Brit. Med. Jour., June 23d, 1888.—Pfeiffer: Fort. der Med., 1888, No. 1, p. 33.—For further detail the reader is referred to the article of Nichols (Trans. Am. Orth. Assn., vol. xi.), which has been freely used by the writers.

[4] Cheyne: "Tuberculous Disease of Joints." p. 97.

regarded as other than inaccurate, and only approximating the truth, but the error is likely to lie always on one side, in making the proportion of inheritance too small.[1]

Traumatism.—Experimentally it has been shown that trauma to the joint of a tuberculous animal may cause tuberculous joint disease, but that it does not do so in the healthy animal. It has been established that contusions and wrenches cause the effusion of blood in the spongy tissue of the bone. Cases are seen in which tubercles develop directly from the clot, just as in a syphilitic individual a gumma may develop at the site of an injury to the bone. "There are cases in which the swelling from the fall merges into the tuberculous swelling."[2] It would therefore seem rational to assume that trauma caused tuberculous joint disease in children who inherited a constitutional taint. But it becomes evident at once that this is not all, for every surgeon of experience must have in his mind cases in which joint disease of a tuberculous type has followed injury in children whose family histories were exceptionally good.

From one-sixth to one-half of all cases would appear from the collected statistics to be traumatic.

In certain cases traumatism alone must be accepted as the causative factor, while in some cases no cause can be assigned.

The *exanthemata* must be mentioned as being the cause of tuberculous joint disease in a certain proportion of cases, probably a larger proportion than has been suspected. Measles and scarlet fever are the most common eruptive diseases to be followed by these sequelæ. There are very few figures bearing upon the subject. The effect of the exanthemata in causing other forms of joint disease will be alluded to later.

The entrance of the bacilli is apparently most often through the respiratory and digestive tracts.

It is probable that whatever continuously diminishes the power of resistance and of repair in growing children increases what may be termed the vulnerability of the epiphyses, and furnishes the soil for the development of tubercle bacilli and the consequent results.

Age.—Tuberculous joint disease is pre-eminently a disease of childhood. It is not congenital, and under one year it is not common. The majority of cases occur between three and ten years of age.[3]

[1] Gibney: "Strumous Element in Joint Disease," N. Y. Med. Jour., July, 1877.—From preface of German translation of "The Mechanical Treatment of Pott's Disease."—Croft: Clin. Soc. Transactions, London, vol. xiii.—Nichols: Orth. Trans., xi., p. 358.

[2] König: Deutsch. Zeit. für Chir., 1879, xi.

[3] N. M. Shaffer: "Am. Clin. Lectures," vol. iii., 141; Sonnenberg: Arch. f. klin. Chir., 1881, xxvi., 789; Lannelongue: Loc. cit.—"Hip Disease in Childhood," p. 2.—L. A. Sayre: "Orthopedic Surgery and Diseases of Joints."

The liability of the aged to tuberculous joint disease must not be overlooked.[1] The patients may be seventy-five or ninety, and cases of hip disease present the same pathological appearances here as in young children. The course of the disease is more rapid and destructive than in the young, and its etiological relations are decidedly more obscure.

The reasons why tuberculous joint disease affects children to so great an extent are as follows:

In the active period of growth more change is going on and therefore more instability exists and consequently greater liability to disease. Children are more liable to falls and injuries, which are such a fertile source of joint and bone lesions. It is not till after puberty that the process of natural selection has eliminated the weaklings from the stock. Children are kept quiet less easily than adults, and a slight injury may develop into a formidable disease. Tuberculosis in general is common in childhood.

Sex is not a factor of any prominence, but there is a slightly larger proportion of tuberculous joint disease among boys than among girls.[2]

Distribution of Chronic Tuberculous Joint Disease.—The relative frequency with which tuberculosis attacks the various joints in children may be estimated from the following figures:

At the Children's Hospital, from 1869 to 1903 inclusive, 5,950 cases of tuberculosis of the joints were distributed as follows: spine, 2,867; hip, 2,281; knee, 375; ankle, 394; elbow, 33. These practically all occurred in children under the age of twelve.

In 211 cases of joint tuberculosis among the out-patients occurring in children under two years, there were 120 cases of Pott's disease, 61 of hip disease, and 29 of tuberculosis of the knee-joint.[3]

Judson has called attention to the great preponderance of joint disease in the lower extremity as contrasted with the upper limb. Analyzing the reports of two orthopedic institutions in New York City, he found that in a single year the following number of cases of disease of the different joints were treated:

Hip-joint disease	577
Knee-joint disease	181
Shoulder disease	6
Elbow disease	8

or 758 patients had disease of the joints of the lower extremity, while in the same time there appeared only 14 cases of joint disease in the upper extremity.

In joint disease, when one or more articulations are involved, any

[1] "Clinical Lectures and Essays. Senile Scrofula," 2d ed., p. 345.
[2] Gibney: Loc. cit., p. 206.
[3] Thorndike: Orth. Trans., ix., p. 196.

combination may be found; but the most common are hip disease and Pott's disease, knee disease and Pott's disease, and double hip disease. Disease of the knee- and hip-joint at the same time is not common, and double tumor albus is unusual.

DIAGNOSIS.

The recognition of tuberculous joint disease is to be based upon certain general phenomena modified by the anatomical conditions of the joint affected. These diagnostic signs are considered in connection with the individual joints.

The use of *tuberculin* as a means of diagnosis is open to the criticism that its results are attended with so much uncertainty that its value in the individual case is always open to question and cannot be assumed to be a reliable demonstration that tuberculosis is either present or absent in that case.[1] It has been demonstrated that in a certain per cent of well-marked cases of pulmonary or other tuberculosis, tuberculin gives a negative result, while in other cases, presumably non-tuberculous, a certain percentage of positive results is obtained. The great frequency of tuberculous invasion has been shown by the autopsies of Babes,[2] for example, who found lesions of the bronchial glands in more than one-half of his autopsies on children; and those of Naegeli,[3] who found, in 508 consecutive autopsies, that 97 to 98 per cent showed evidences of tuberculosis. Under these circumstances tuberculin must necessarily be unreliable in demonstrating joint tuberculosis.[4]

The *inoculation* of material from suspected joints into guinea-pigs forms a reliable means in the diagnosis of tuberculosis of the joints.

The *x-ray* is an aid in the diagnosis of joint tuberculosis where the process is sufficiently advanced to have caused the absorption of lime salts in the affected area or to have destroyed any part of the bony structure. In early cases the radiograph may be normal when disease is present.

PROGNOSIS.

The destructive process which is so prominent a feature of joint tuberculosis is almost from the first accompanied by a reparative process tending to limit the destruction, protect the surrounding tissues, and prevent generalization. The prognosis depends in the individual

[1] F. W. White: Boston Med. and Surg. Journal, August 5th, 1898 (with bibliography).—Schlüter: Deutsch. med. Woch., 1904, viii., 30, p. 272 (with literature). Brit. Med. Journ., 1903, vol. ii., pp. 48, 96.

[2] Babes, quoted by Burrell: "Surg. Tub.," Trans. Mass. Med. Soc., xix., 1903.

[3] Naegeli: Arch. für path. Anat., vol. clx.

[4] "Indirect Tuberculin Reaction." Bull. de l'Institut Pasteur, t. ii., April 30, 1904, p. 333.

case upon which of these two processes prevails over the other. The former is favored by inefficient local treatment, bad inheritance, poor general condition, unfavorable surroundings, and, in general, what may be termed poor resistance to the tuberculous process. The reparative process is favored by the reverse of these conditions. In the majority of all cases of joint tuberculosis, properly treated at a fairly early stage, the outlook is favorable. The prognosis is more favorable in children than in adults.

TREATMENT.

Since bone tuberculosis has been shown to be one manifestation of tuberculous infection and not the result of an unknown evil, the principles of treatment are more clear.

Resistance to the infection by the tubercle bacillus is furnished when the individual is in a normal state. The antidotes to be relied upon to check its advance after it has found lodgment are not only good air and food, but such general activity as will promote normal metabolism. Tuberculosis is prevalent and fatal among caged animals—a fact which is to be borne in mind in the treatment of bone tuberculosis.

The treatment is both general and local. The general treatment consists in giving the patient the best possible environment and in furnishing such conditions that normal activity will cause the least possible injury to the part locally affected.

In tuberculosis of the lung the patient is in constant danger of self-infection or increase of the process from the inhalation of infected material. In bone tuberculosis no such danger exists. Strong, well ossified bone does not offer suitable soil for the bacillus. Bone tissues when invaded resist the advance of tuberculous infection by surrounding the diseased area with a thick enveloping mass of tissue and by subsequently repairing the invaded region by the development of strong bone. Traumatism, which injures this bone construction and furnishes undeveloped cells instead of firm bony structure, favors the spread of the tuberculous process.

The treatment of bone tuberculosis, therefore, consists in promoting such general conditions as will favor repair (general treatment) and the protection of the parts from injury during the disease (local treatment).

General Treatment.—The patient should be placed in the most favorable environment available in the matter of food, home surroundings, air, sunlight, proper clothing, exercise, avoidance of fatigue, and similar requirements.

Outdoor Treatment.—Of these requirements outdoor air is of the utmost importance, and the open-air treatment of surgical tuberculosis[1] is nowhere more beneficial than in joint disease. The outdoor

[1] Burrell: Comm. Mass. Med. Soc., 1903, xix., 11, p. 303.

method recognized as of such value[1] in the treatment of pulmonary tuberculosis is advisable.[2] During the day the patient should be out of doors or in a room with one or more windows open. In winter proper protection against cold should be obtained by warm clothes rather than by heated rooms. Such patients should sleep out of doors in tents or well-aired sheds. During the summer this offers little difficulty, and in the winter such treatment is available even in a New England climate. From Christmas, 1903, through the winter, the patients at the Convalescent Home of the Children's Hospital at Wellesley, with Pott's disease and hip disease, lived and slept in an unheated shed with skylights or doors open. Properly protected by woollen caps and heavy blankets, they suffered no discomfort, and the beneficial effect on the local process was evident.

The importance of the treatment by fresh air and sunlight has been recognized in Europe in the establishment of seaside sanatoriums for children with tuberculous joint disease. It is being recognized in America that a convalescent home in the country is an almost necessary part of a surgical hospital for children.

Drugs.—The writers are of the opinion that drugs, except tonics when required, are of little or no value in the treatment of joint tuberculosis.

Local Treatment.—*Fixation*, *distraction*, and *protection*, along with *operative treatment*, are considered in speaking of the individual joints. Other local measures are occasionally of use, in addition.

Bier's congestive treatment[3] depends upon hyperæmia as a therapeutic agent, and in connection with proper mechanical treatment it may be of benefit in the knee, ankle, elbow, or wrist. A congestion of the affected joint is induced by bandaging above and below the joint with cotton webbing or rubber bandages and allowing the congestion to continue for an hour daily. The congested parts should feel warmer than the normal skin, but the process should never be pushed to the degree of causing pain.

X-ray treatment consists in an exposure of the affected joint to the *x*-rays for a certain period every day or every second day. In a fairly large number of cases of joint tuberculosis under mechanical treatment treated in this way in addition, checked by cases under similar conditions not so treated, the writers have not been able to detect any benefit from the use of the *x*-ray.

Counter-irritation, *inunction*, *igni puncture*, and similar measures

[1] Med. Record, November 18th, 1902, p. 736. Am. Med., March 21st, 1903, 440. Münch. med. Woch., 1902, xlix., 1081.

[2] Zeitsch. f. Tub. und Heilstätt., July, 1902, pp. 366 and 369.

[3] Frieberg: Am. Journ. Orth. Surg., August, 1904, ii., 150.—Luxembourg: Münch. med. Woch., 1904, 10.

have fallen into more or less disuse since the better appreciation of the pathology of joint tuberculosis and the essentials of its treatment.

Massage, *manipulation*, *hot-air baths*, *douches*, and similar measures to stimulate the local circulation are to be avoided during the acute stage of the process as essentially undesirable. In late convalescence they may prove of much value.

CHAPTER II.

TUBERCULOUS DISEASE OF THE SPINE.

Definition. — History. — Pathology. — Occurrence and Etiology. — Symptoms. — Complications. — Diagnosis. — Differential Diagnosis. — Prognosis.— Treatment.

Definition.—Pott's disease is the name applied to a destructive pathological process which attacks the bodies of the vertebræ. The other names by which the affection is known are as follows: Spondylitis, *Malum Pottii*, Caries of the spine, Kyphosis, Angular curvature, Tuberculosis of the vertebræ, and Spinal curvature. In German it is known as *Die Pott'sche Kyphose, Spitzbuckel, Winkelförmige Knickung der Wirbelsäule*, and *Tuberculose Wirbelentzündung;* in French as *Cyphose, Mal de Pott*, and *Mal Vertébral*.

History.—Antero-posterior curvature of the spine is an affection which was described by the ancients, and was known to Hippocrates and Galen, who attributed its cause to tubercle "within and without the lungs." Ambroise Paré wrote of it and used a metal cuirass in its treatment, but it was not until the time of Percival Pott, in 1779, that any accurate description of the disease was given.[1] In honor of that surgeon the disease is chiefly known by his name. The existence of the disease in prehistoric times in North America is proved by a specimen in the Peabody Museum, Cambridge, Mass.

PATHOLOGY.

Pott's disease represents the result of a destructive ostitis affecting the spongy tissue of one or more of the vertebral bodies. This ostitis is tuberculous in type and follows the same course as tuberculous ostitis occurring at the epiphyses of the long bones, as in hip disease, tumor albus, etc.

The first appearance noticeable to the naked eye on examining a section of a diseased vertebra at an early stage of the disease is a small hyperæmic spot in some part of the spongy portion of the body of the vertebra, generally near the anterior surface of the body. This spot grows larger and more red as the process extends, and finally the centre becomes opaque and grayish, while a zone of hyperæmia surrounds

[1] Pott: "Remarks on that Kind of Palsy Affecting the Lower Limbs," etc., London, 1779.

it. A focus of tuberculous ostitis is present. If this process extends, the opaque spot becomes larger, and finally cheesy degeneration of its centre takes place. At other times both caseation and degeneration into tuberculous pus take place, and a localized abscess of bone exists, probably encapsulated in a membrane of inflammatory tissue, which surrounds the focus, endeavoring to protect the surrounding healthy bone

FIG. 7.—Pott's Disease Involving the whole Dorsal Region. Prehistoric Indian remains. (Peabody Museum, Spec. 17,223.)

from the erosive action of the focus. Microscopical examination shows a mass of tubercles in a rarefied spongy bone tissue, and in the tubercles are to be found tubercle bacilli.

The focus of tuberculous material may either be absorbed or calcified, or, as happens much more commonly, the ostitis may increase until it has destroyed a large part or the whole of a vertebral body. In its course of enlargement it may include portions of bone, the nutrition of which is cut off by the adjacent inflammatory destruction. Such portions necessarily become necrosed, and with caseous matter, granulation tissue, and the products of inflammation constitute an area of altered and degenerated structure in the vertebral body. If this diseased area has become large enough, the vertebral body gradually becomes incapable of sustaining as much pressure as before. From the

peculiar weight-bearing function of the vertebral column, the pressure upon each vertebral body is always considerable when the vertebral column is in the erect position. If one vertebral body is becoming excavated, a point will be reached where it can no longer sustain the weight, but must give way slowly or suddenly. A forward tilt of the whole vertebral column above the seat of disease is then inevitable, with a certain amount of backward angular deformity at the diseased vertebra. This is the mechanism of the production of the knuckle in the back.

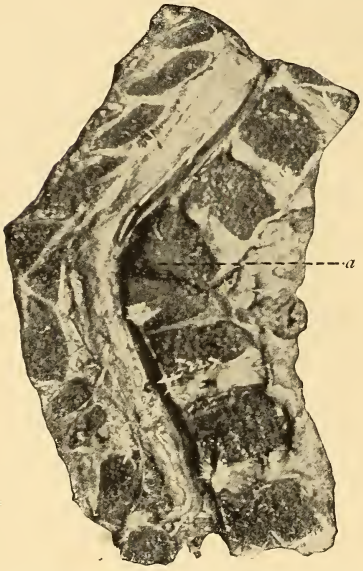


FIG. 8.—Lower Dorsal Region. One intervertebral disc destroyed. Extension of process backward to dura and formed along prevertebral ligaments. Moderate knuckle hardened in upright position, so that gravity pressed diseased vertebræ together. *a*, Tuberculous softening. (Nichols.)

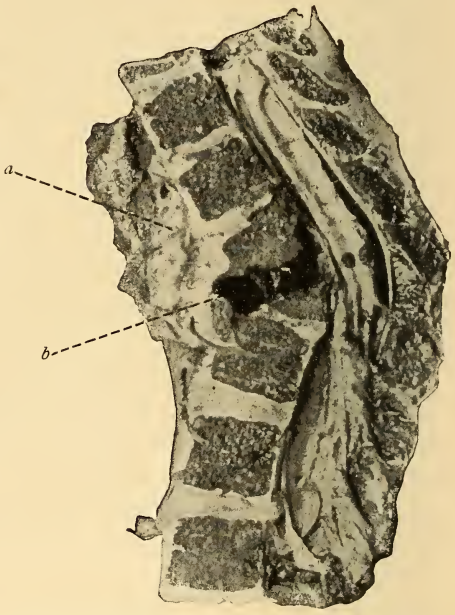


FIG. 9.—Lower Dorsal Region. Opposite half of specimen rested on knuckle while hardening, so that gravity extended the spine. Marked separation of diseased vertebræ. *a*, Tuberculous disease beneath prevertebral ligaments; *b*, cavity between diseased vertebræ. (Nichols.)

It is, in brief, a softening and crushing of one or more vertebral bodies and a giving way of the column at that point as a necessary mechanical result.

This process is limited, as a rule, to the vertebral bodies; the transverse, articular, or spinous processes are rarely affected secondarily or primarily, their structure of hard bone apparently protecting them from tuberculous invasion.

The intervertebral cartilage between the diseased vertebræ becomes fibrillated and disintegrated and disappears.

There may be two or more foci in one vertebra, or the whole body may be equally affected; the disease may be limited to one spot, forming

a localized abscess of the bone, or it may extend so as to involve the adjacent vertebræ. If the disease remains limited to the centre of the vertebra, but little deformity may result. Primary disease of two vertebral bodies in different, non-adjacent parts of the spine is rare. But an extensive destruction of two or more adjacent vertebræ from primary disease of one may be said to be the rule in Pott's disease. In some instances this destructive process may be limited to the surfaces of a large number of vertebral bodies; in others a few contiguous ver-

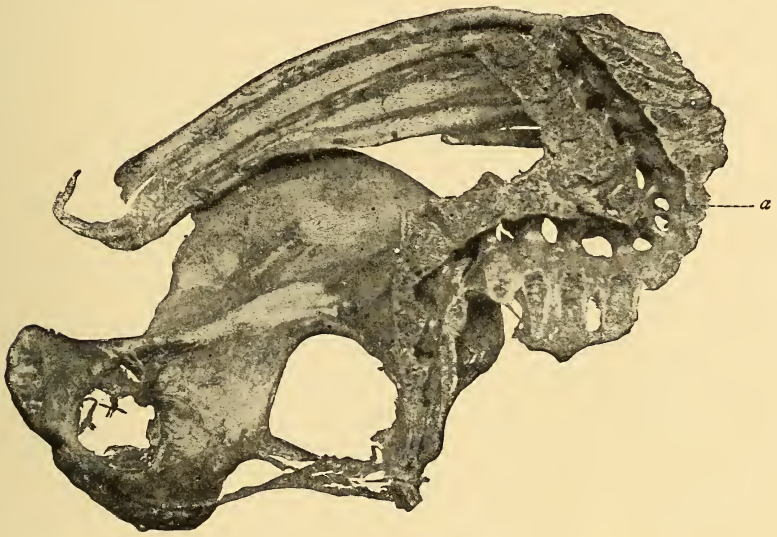


FIG. 10.—Spine, Lower Dorsal and Lumbar Region. Extreme knuckle. Lower ribs rest on pelvis. Change in angle of ribs due to continued deformity. Calibre of spinal canal not diminished. *a*, Knuckle. (Nichols.)

tebral bodies are completely destroyed. The number of vertebræ involved necessarily varies; in some instances the bodies of twelve or even more have been destroyed, producing a deformity which involves almost the whole of the spinal column. A superficial ostitis of the anterior surfaces of the bodies, without involving the intervertebral cartilages or impairing the weight-bearing function of the vertebræ, occurs, but is rare.

Abscess.—"In a considerable portion of cases of tuberculous disease of the spine no abscess is recognized during life, but in cases seen at autopsy an abscess is almost invariably found, although it may be of small size. The tuberculous material early pushes up the prevertebral ligaments and forms a flattened, soon a nodular swelling in front or sometimes to one side of the vertebræ. The contents of such a swelling are like the contents of other tuberculous abscesses" (Nichols).[1]

[1] Nichols: Orth. Trans., vol. xi., p. 391.

In certain cases the formation of tuberculous pus is a characteristic of the disease from the first, and in these cases abscesses are apt to be a conspicuous feature. The tuberculous pus finds its way, during or after the destruction of the body of the vertebra, into the surrounding tissues and gravitates downward. It appears usually in the course of the sheath of the psoas muscle when the disease is situated in the lower half of the spine, but the site of the abscess necessarily depends upon the place of the original disease, and may be in the mouth —as in retropharyngeal abscess —in the neck, in the axilla, or in the back, lungs, abdomen, or groin. The contents of such abscess as a rule contain no pyogenic bacteria.

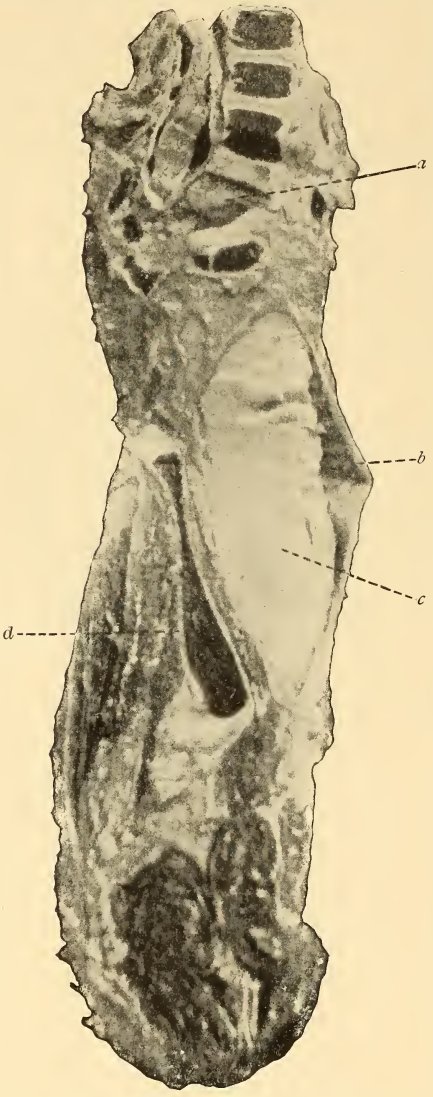


FIG. 11.—Lower Lumbar Region. Section obliquely through lumbar vertebræ and ilium in the line of the ilio-psoas muscle. Small tuberculous area in lowest lumbar vertebra. In pelvis is large tuberculous abscess in sheath of ilio-psoas muscle. *a*, Tuberculous focus in lumbar vertebræ; *b*, peritoneum and sheath of ilio-psoas; *c*, abscess; *d*, ilium. (Nichols.)

Paralysis.—In certain cases meningitis and myelitis are present in the cord opposite the seat of disease, accompanied sometimes by what is virtually the destruction of the cord at that point. The paralysis is very rarely caused by direct pressure of bone, as it is uncommon for even very marked deformities of the spine to narrow the spinal canal to any great extent. Moreover, paralysis sometimes occurs before there is any deformity, and it often recovers while the deformity gets worse. Many cases with extreme deformity are never paralyzed at all. In 52 cases collected from literature by Schmaus[1] in which autopsy afforded a chance of determining the cause of the paralysis, compression was mentioned as a cause

[1] Schmaus: "Die Compression-Myelitis der Caries," etc., Wiesbaden, 1890.

in only 39 cases; in 33 of these a caseous pachymeningitis was noted. In 6 bony pressure existed, and in 5 of these the odontoid process of the axis was dislocated. In only 1 was kyphotic displacement the cause of the pressure. Kraske[1] estimates bony pressure as the cause in two per cent of the cases. Autopsy shows that in cases of paralysis the process ordinarily begins as an external pachymeningitis. Compression from thickened meninges must therefore be classed as one cause of paralysis. This meningitis is generally clearly tuberculous in character. Myelitis or, better, meningomyelitis,

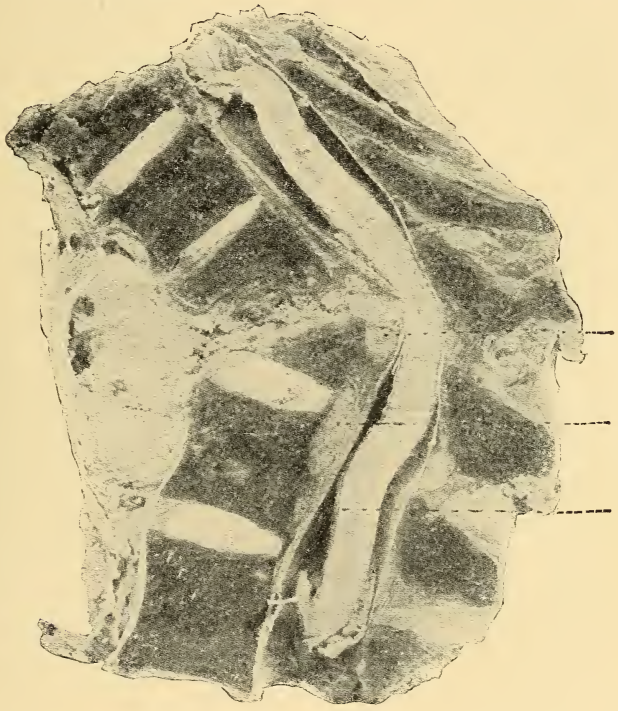


FIG. 12.—Sagittal Section of the Spine from the 9th Dorsal to the 2nd Lumbar. Compression of cord and abscess. (Schulthess.)

however, at times exists from an early stage in the cord itself. This is not to be demonstrated as tuberculous by the microscope. This meningomyelitis is followed, if it is severe enough, by ascending and descending degenerations in the columns of the cord. Œdema also is present, at first apparently non-inflammatory in character, but later inflammatory. This also must be a factor in producing symptoms, and alone explains the immediate improvement in certain cases after forcible rectification of the deformity. Thrombosis and embolism of spinal vessels must be accounted as possible factors in contributing to the

[1] Kraske: Archiv f. klin. Chir., vol. lxi.

disturbance in the cord. The order of changes is as follows: œdema, diffuse softening, and sclerosis. If the myelitis ceases, it leaves a certain amount of sclerosis of the cord at the seat of the disease. This, again, may be very slight, or the cord may be reduced to a fraction of its former size, and yet serve well enough to transmit healthy nervous impulses.

There may be a direct strangulation of the cord by the vertebral arches, obliterating the canal; or an abscess from diseased bone may be

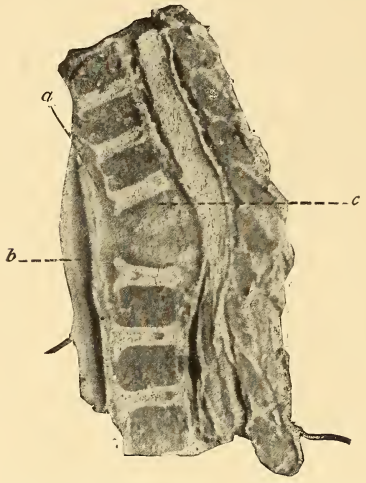


FIG. 13.—Tuberculosis of Lower Dorsal Region. Large area of tuberculous softening involving two vertebræ. Intervertebral disc destroyed. Process extends forward beneath prevertebral ligaments and pushes aorta forward. Process also extends backward to dura. *a*, Beginning abscess; *b*, aorta; *c*, tuberculous softening of vertebræ. (Nichols.)

FIG. 14.—Lower Dorsal and Upper Lumbar Vertebræ. Tuberculous softening in anterior portion of bodies of five vertebræ. Marked knuckle. Portion of one vertebra pushed backward into spinal canal, but does not produce pressure upon spinal cord. *a*, Tuberculous disease of vertebra; *b*, tuberculous foci; *c*, cord; *d*, fragments of bone projecting into spinal canal. (Nichols.)

a source of pressure within the canal. A caseous deposit from the vertebræ and a loose piece of bone have been found as sources of pressure.

In proportion to the extent of the disease and the number of vertebræ involved, an angular deformity of the spine may be present to any extent. In severe cases this angular deformity leads to many secondary pathological changes. The shape and capacity of the chest are necessarily very much altered, and the ribs sometimes sink into the pelvis. As a result of these changes in chest capacity, hypertrophy of the heart, often accompanied by valvular disease, is common. The aorta may be distorted as a result of the deformity. Thomas Dwight reports a case in which its course "might be compared to an S lying on its side, with the ends bent strongly back to fit around the promi-

nence of the spine."[1] Lannelongue[2] found a very marked narrowing of the calibre of the aorta in many cases. Sometimes it was reduced even to a mere slit.

A cure, however, is possible even in cases with very advanced deformity. This cure can come about in one of two ways: (1) By ankylosis between the surfaces of the bodies of the diseased vertebræ—a very slow process, which requires years for its completion; (2) by the deposit of bone in the inflammatory material, thrown out around the column by the action of the formative ostitis which accompanies the destructive process, the vertebral column being supported, as it were, in surrounding bone.

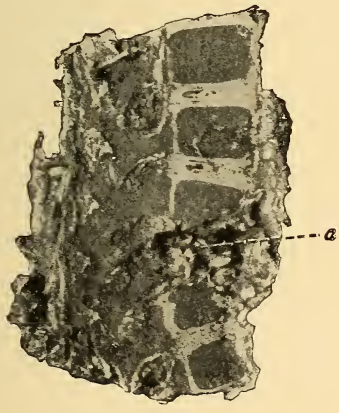


FIG. 15.—Lower Dorsal Region. Extensive tuberculous softening involving two vertebræ; intervertebral disc destroyed. Knuckle very slight, probably because the focus was in the centres of the vertebral bodies, and laterally destruction was not complete. *a*, Tuberculous cavity, involving centres of bodies of two vertebræ. (Nichols.)

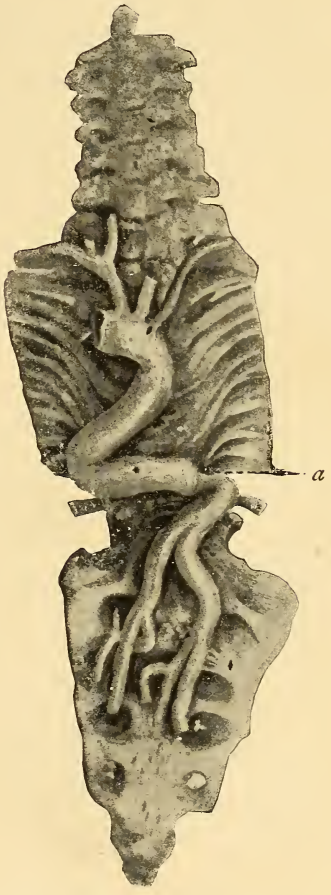


FIG. 16.—Distortion of Aorta. From a case of spinal caries in an adult. At one point marked constriction of the aorta. Angular deformity very marked. *a*, Constriction of aorta. (Dwight.)

OCCURRENCE AND ETIOLOGY.

Sex.—Sex does not appear to be an important factor in causing Pott's disease, though statistics vary somewhat.

Age.—The disease is more common in childhood. Mohr found, in

[1] Dwight: Amer. Jour. Med. Sciences. January, 1897.

[2] Rev. de Chir., August 10th, 1886, p. 671.

72 cases, that the disease occurred between the first and fifth years in 29 per cent; between the sixth and tenth years in 22 per cent; between the eleventh and fifteenth years in 22 per cent; between the sixteenth and twentieth years in 16 per cent; and above the twentieth year in 11 per cent. Drachman found in 161 cases 41 per cent between one and five years, and 36 per cent between five and ten years. The oldest patient was seventy-seven years of age, and the youngest eight weeks. Gibney found that 87 per cent were under fourteen years of age; 7 per cent between fourteen and twenty; and 4 per cent over twenty-one. Taylor found in 375 cases that 226 were under five; 68 between five and ten; and 24 between ten and fifteen.[1]

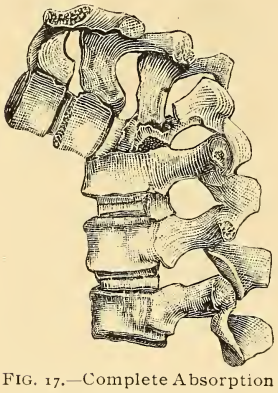


FIG. 17.—Complete Absorption of Vertebral Body. (Warren Museum.)

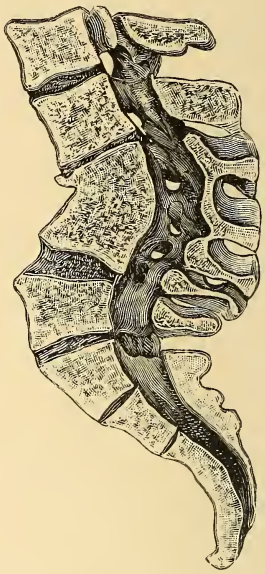


FIG. 18.—Complete Bony Ankylosis. (Warren Museum.)

Localization.—Any of the vertebræ may be attacked, but in varying frequency. As there are more dorsal vertebræ than either cervical or lumbar, it is natural that the number of cases of dorsal disease should be greater than in the other regions.[2] Dollinger in 538 cases determined the vertebræ originally affected to be as follows: cervical, 63; dorsal, 321; lumbar, 154. The most frequent seat was between the twelfth dorsal and first lumbar. The upper half of the column was affected primarily only 117 times. In a series of 1,355 cases from the Hospital for the Ruptured and Crippled, the distribution was as follows: cervical, 100; dorsal, 854; lumbar, 317.

Although, as is seen, the locations of relative frequency given by the different observers do not agree, it would appear that certain por-

[1] New York Med. Record, August 13th, 1881.
[2] Disse: "Skeletlehre," 1896.

tions of the spine are more liable to attack than certain others, and that the regions most liable to the disease were those which were the most exposed to jars or increased pressure; and that the disease would be more frequent where the hinges of motion at the spinal column came, varying to a degree according to age and occupation, or where there was the greatest exposure to the effects of violent jars.

Causation.—It may thus be assumed that the localizing cause of Pott's disease is jar or superincumbent pressure; the influential cause being that physical state which is incapable of resisting slight trauma, exposing the tissue probably to the invasion of the tubercle bacillus.

Gibney, in an examination of 185 cases, found a hereditary tuberculous taint in 76 per cent. In 45 per cent a weakened condition from previous sickness was found; and in 22 per cent both an inherited and an acquired diathesis were found. Taylor, in 845 cases, found 53 per cent with a history of preceding trauma (Vulpius, in 810 cases, found the same percentage [53]); in 15 per cent there was disease of the lungs in nearer or more distant relatives; in 19 per cent so-called scrofula was asserted; and in 34 per cent a sickly condition. Vulpius found a history of hereditary tuberculosis in 16 per cent of his 810 cases.

FIG. 19.—Attitude in Cervical Caries of only Moderate Severity.

FIG. 20.—Attitude Assumed by Children with Acute Pott's Disease, and in Other Cases Necessitated by Psoas Contraction.

SYMPTOMS.

Few affections have a clinical history which varies so widely and appears under such different guises as that of Pott's disease. The one

constant symptom, however, which accompanies all cases of Pott's disease and must often form the chief reliance in diagnosis is muscular rigidity at the affected portion of the spine. Just as spasm of the joint muscles is the constant symptom of chronic joint disease, so is restricted motion between the diseased vertebræ the constant accompaniment of Pott's disease, in its early or later stages.

FIG. 21.—Attitude in Severe Pott's Disease with Psoas Contraction.

Typical cases of Pott's disease are so characteristic in their symptoms that the diagnosis is evident almost at a glance. The guarded character of all the movements is perhaps the most striking feature. In walking, in stooping, or in lying down, the spine is most carefully guarded against jar and against motion, attitudes are assumed which relieve the vertebral column of some of the weight of the body, and a glance at the naked child shows unnatural modes of standing and walking.

A prominence of the vertebræ is ordinarily present as early as at this stage, and oftener than not pain is acute and aggravated by motion. Constitutional disturbance is also very likely to be present when the disease has been of even a few weeks' duration. Loss of flesh and appetite and inability to go about much without fatigue are often among the first symptoms to attract attention.

Peculiarity of attitude and gait, muscular stiffness, and referred pain are the most prominent of the earlier symptoms, and they may be present be-

FIG. 22.—Attitude of Head in Cervical Pott's Disease.

fore a projection has been noticed. The importance of recognizing these early symptoms can hardly be overstated, as it is on an early recognition of the affection that the hope of a ready cure is to be based.

Attitude.—The peculiarity in attitude noticed early in the disease is due either to reflex muscular spasm—similar to that seen in joint disease—or to an unconscious effort on the part of the patient to prevent jar or any increased pressure upon the affected vertebral bodies. These attitudes necessarily vary according to the point of the spine at-

FIG. 23.—Lordosis in Lumbar Pott's Disease.

FIG. 24.—Deformity in Dorsal Pott's Disease Showing Spasm of Muscles.

tacked. In disease of the upper cervical region, the most common attitude is that of wry-neck.

When the disease is in the *lower cervical* or *upper dorsal* region, the chin is held somewhat raised, to balance the weight of the head on the articular facets, suggesting the position of a seal's head when out of water. The spinal column below the point of disease is abnormally straight, and in some instances curved slightly forward, while in the lower dorsal region an exaggerated backward projection of the spinous processes may be seen; this projection, due to a compensating curve,

is sometimes so marked as to suggest that the disease has attacked another part of the spine.

In the *middle dorsal* region the attitude to be noticed most frequently is an elevation of the shoulders. Temporarily a slight lateral deviation of the spine is to be seen.

In the *lumbar* region, the patients in the early stage frequently will be noticed to lean backward, like pregnant women or adults with large abdomens. A peculiar position and characteristic sidling gait, which is sometimes seen at a comparatively early stage of disease in the lower dorsal or lumbar region, is due to a slight contraction of the psoas and iliacus muscles.

In a late stage, when psoas abscess is present, a marked contraction of these muscles takes place; but even when there is no evidence of

FIG. 25.—Acute Pott's Disease; Supporting Body by Arms.

existence of suppuration or of a psoas abscess, slight inflammatory irritation of the muscles will produce a limitation to the arc of extension of the thigh on the trunk.

In general, in addition to the square position of the shoulders, the peculiar position of the head, and the erect attitude of the upper part of the spine, which prevents the superincumbent weight of the trunk and upper extremities (above the diseased portion of the spine) from falling forward upon the diseased vertebral body, the gait is peculiar; the patient walks more on the toes than on the heels, and with the knees slightly bent—in such a way that all possible springs may be brought into play to diminish the jarring of the spine.

These peculiarities of attitude and position vary in severity according to the acuteness of the disease; they may be at one time more noticeable than at another. Characteristic also at this stage of the disease is a muscular stiffness, which becomes more marked after the patient has been quiet for a while (during sleep). The stiffness of the limbs diminishes or disappears after the patient has moved about. A certain amount of muscular rigidity of the muscles of the back will be felt on palpation in affections of the middle dorsal and lumbar regions; stooping which involves arching of the back forward is difficult or impossible in disease of the lower spine, and in attempting to stoop in

FIG. 26.—Severe Grade of Psoas Contraction.

FIG. 27.—Lateral Deviation of Spine from Dorsal Pott's Disease.

order to pick up any article from the floor the patient will keep the spine erect and reach the floor, lowering himself with an erect trunk, by bending the knees.

It will often be noticed that children become tired more easily than usual, and after playing about for a time will desire to lie down, to rest their arms upon a chair or seat, or to support the head with their hands, or the trunk by holding on to the thighs, according to the part of the spine affected.

The amount of muscular stiffness, rigidity, and difficulty in main-

taining the spine erect is in a measure an index of the degree of activity of the disease. In early cases the muscles on either side of the area of the affected vertebræ will often, on bending the back, be seen to spring out in relief, acting like physiological splints to the diseased vertebral column.

Various modifications of characteristic attitudes are at times produced. The most common of these probably is the flexion of the thigh which results from psoas contraction, usually the result of psoas abscess. The contraction of the muscle is both the warning and the accompaniment of the abscess. It may be present to such a degree that the leg cannot be put to the ground in walking and the use of a crutch is necessitated.

FIG. 28.—Lateral Deviation of Spine in Dorsal Pott's Disease. Back view.

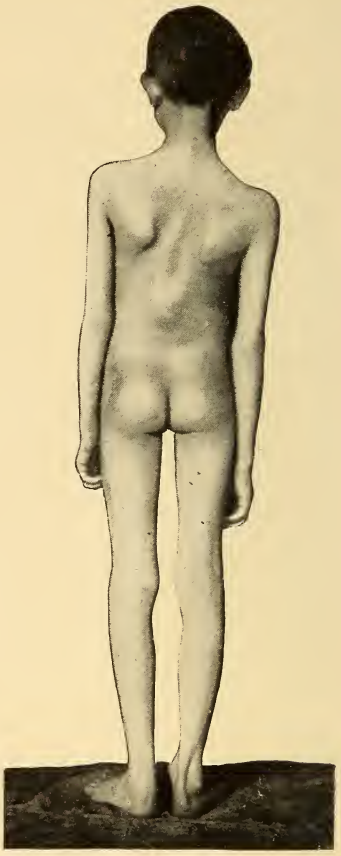


FIG. 29.—Lateral Deviation of Spine in Lumbar Pott's Disease.

Lateral deviation of the spine is an attitude to be found in Pott's disease and is discussed in its relation to lateral curvature under the head of diagnosis. As a rule, the lateral curve of Pott's disease is characterized by very slight, if any, rotation of the spinal column on a vertical axis.[1]

The lateral deviation has no especial significance except in indicat-

[1] Annals of Surgery, July, 1889.

ing a certain modification of treatment to be considered later. It is most severe in acute cases. The divergence may reach 8° from the perpendicular at its maximum point,[1] and in thirty cases measured by the writers did not exceed this; 5° makes a divergence enough in amount to make the fitting of apparatus difficult. This divergence is diminished by the recumbent position. It is sometimes the first symptom of Pott's disease, and one which has attracted but little attention.

Pain.—In certain cases of Pott's disease pain is absent altogether, but it is often present to a most distressing degree, and it forms a more prominent symptom than it does in hip disease or tumor albus, for instance. In a measure it tends to mislead both parents and physician, for the pain is rarely complained of in the back, but is referred to the peripheral ends of the nerves, and is thus described as being felt in the abdomen, chest, or limbs. Chipault has described a class of cases in which severe pain in the kyphus is present, and has given to the condition the name "apophysalgie Pottique."[2] Abdominal pain passes for

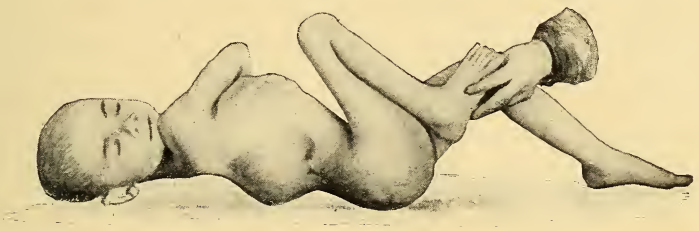


FIG. 30.—Case of Neglected Pott's Disease with Psoas Contraction and Severe Deformity.

"stomach-ache," and pains in the limbs for "growing pain" or rheumatism. In general, it may be said here that persistent localized pain in the case of a child is a symptom demanding very great attention.

The sleep of these children is apt to be much disturbed by pain, for the suffering from Pott's disease, like all the pain of bone diseases, is more severe at night. In the milder cases this is manifested by simple restlessness, while in more severe cases it takes the form of crying spells. This may even be the case when the children can walk about without pain during the day. As a rule the pain is aggravated by exercise, jars, and wrenches. It is not always elicited by pushing down on the child's head. Superficial sensitiveness over the spinous processes is not a symptom of Pott's disease.

The pain is usually subacute, and may be only occasional. At times the attack may be very severe, accompanied by intense hyperæsthesia, so that the pressure of the bedclothes cannot be tolerated, and patients in this condition have been supposed to have intense peritonitis or pleurisy. The subacute form is more common, and this, togeth-

[1] Orth. Trans., iii., 182.

[2] "Trav. de Neurologie Chir.," 1898.

er with muscular stiffness, often gives rise to a diagnosis of rheumatism, sciatica, or neuralgia. Analogous to these attacks of pain are disturbances of the functions of other nerves—manifested in cough, peculiar grunting respiration, dyspnœa with cyanosis, gastric disorders, obstinate and recurring vomiting, and troubles of the bladder, with or without pain at the end of the penis. Patients suffering in this way have been treated for bronchitis, pneumonia, gastritis, or cystitis. In one notable instance the operation for stone in the bladder—lateral cystotomy—was performed. No vesical trouble was discovered, but at the autopsy disease of the lumbar vertebræ was found.

FIG. 31.—Result in Severe Case of Dorsal Pott's Disease.

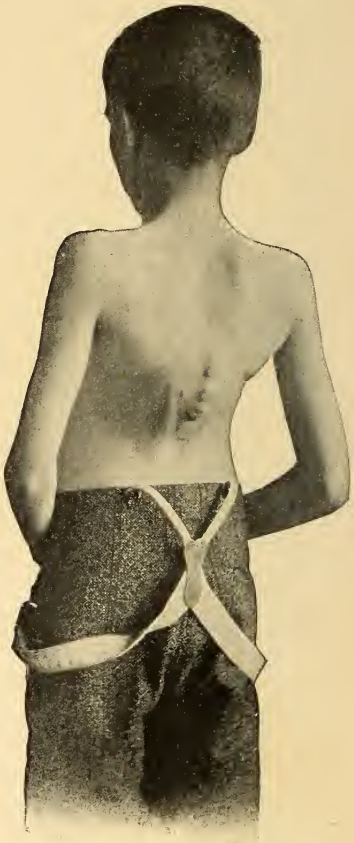


FIG. 32.—Dorsal Pott's Disease with Marked Kyphosis and Backward Projection of Spine.

These periods of suffering may become intense—constituting acute attacks, subsiding after rest, and recurring at intervals without apparent exciting cause.

Eye symptoms may exist in Pott's disease. Partial dilatation ex-

isted in thirty-six out of thirty-eight cases reported by Bull, and neuritis and optic atrophy have been reported.[1]

It is to be expected that pain will be diminished and generally controlled by efficient mechanical treatment. Certain cases, however, are from the first so intractable that pain persists in spite of all that can be done. Fortunately such cases are not the rule, and in general it may be assumed, when pain comes on in the course of treatment, that the apparatus does not fit, if mechanical treatment is used, or that the parents are not careful in the nursing of the child or in carrying out treatment thoroughly. In a few instances it will be found that pain cannot for a time be entirely checked by treatment. A sudden and violent increase of pain should lead one to suspect an approaching access of the disease—with increase of the deformity—the formation of an abscess, or the beginning of paralysis. In cases in which recovery from Pott's

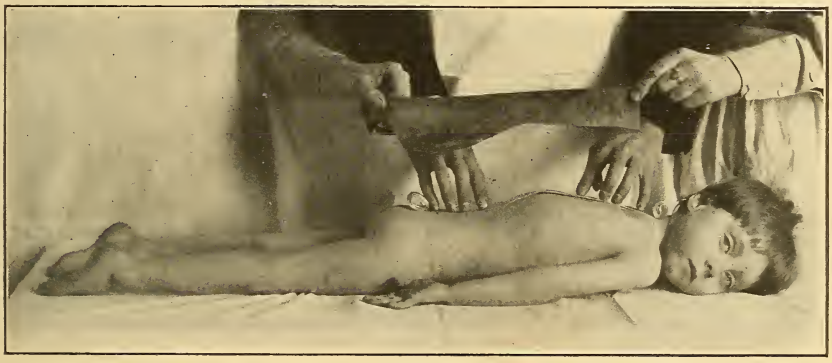


FIG. 33.—Method of Measurement of Deformity in Pott's Disease. Shows lead strip and cardboard tracing. (Children's Hospital Report.)

disease has occurred with great deformity, the lower ribs may have sunk below the crest of the ilium, and by rubbing against it may cause severe pain.

Deformity.—The most characteristic feature of Pott's disease is the deformity—that is, the projection backward of one or more spinous processes. This is occasioned by the destruction of the vertebral bodies. The projection is primarily of the vertebræ first affected, but following this other vertebræ are more or less involved, and the curve increases, with the establishment of secondary curves. The sharper the projection, as a rule, the more acute is the process; but this rule, however true in the upper dorsal region, has occasional exceptions in the lower dorsal and upper lumbar regions. It may be stated that in old cases there is, as a rule, more of a curve and less of an angle. It is not absolutely true that the greater the amount of the disease the greater the

[1] Knies: "Das Sehorgan und seine Erkrankungen," 1893, p. 205.

deformity, for there may be extensive disease on the front of several bodies without diminishing the weight-bearing function of all of them; but, generally, the more vertebræ involved the greater is the projection.

It is most important to keep a record of the deformity in each case under observation. This record is most easily taken by a simple method.

A strip of sheet lead half an inch wide, of the quality known to the dealers as "four pounds to the foot," is made straight by pressing out the curves, and is laid along the spinous processes of the child, who lies on his face on a flat table without a pillow, with his hands at his sides

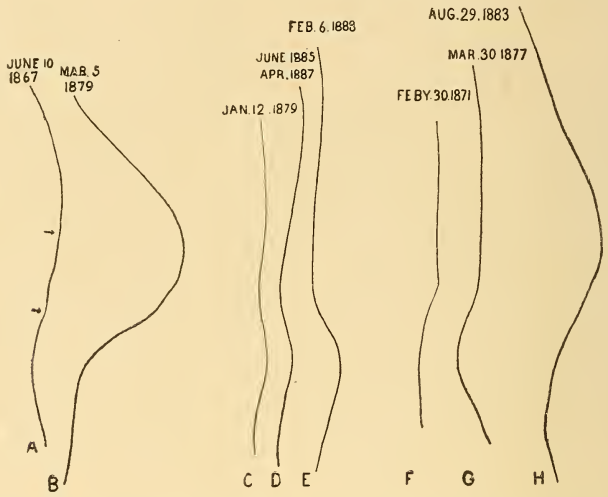


FIG. 34.—Tracings of the Deformity in Pott's Disease. *A B*, not treated; *C D E*, patient did not continue treatment; *F G H*, patient discontinued treatment. (H. L. Taylor.)

and his head turned to one side. With the fingers the lead is pressed against the spinous processes, and when it is removed it is stiff enough to keep its shape. The curve is then drawn upon a piece of cardboard by means of this lead strip, placed on its side and used as a ruler. The cardboard curve is cut out with scissors and the concavity is then applied to the child's back to see if it fits accurately. If not, it should be trimmed with the scissors until it does. The slightest change in the outline of the back can then be detected at any subsequent visit, because any increase or diminution of the deformity will cause the cardboard cutting to fit the outline of the back imperfectly.

If the deformity is left to itself, its tendency is to increase until a spontaneous cure results or death ensues. In many cases in dorsal Pott's disease this result is reached only after an enormous deformity has occurred. In cervical and lumbar Pott's disease spontaneous cure

is more likely to occur, and, when it occurs, is accompanied by much less deformity than in the dorsal region.

When this spontaneous cure occurs, the change takes place gradually and does not cause narrowing of the spinal canal. The gibbosity is most marked in disease of the upper dorsal region, and least in the lumbar region. The secondary curvatures are: in cervical Pott's disease, a dorsal incurvation below the disease, with a slight lumbar excurvation; in dorsal disease, an increased hollowing in above and below the gibbosity of the disease; in lumbar disease, a long curvature with convexity inward above the disease. The neck becomes shortened and thickened in cervical Pott's disease; the trunk is shortened in disease of other parts of the spine; there is also in cases of long duration a diminution of an uncertain origin in the growth of the whole body, so that adults recovered from Pott's disease of ordinary severity are usually of less than average height. In severe cases the limbs more usually grow nearer to the normal amount, and are necessarily out of proportion to the length of the trunk.

FIG. 35.

Taylor[1] has formulated the retardation of growth in patients with Pott's disease as follows:

"Disease of the cervical region is least harmful in this regard; disease of the dorsal, especially the lower half, the most so; while disease of the lumbar region occupies an intermediate position. An average growth of an inch to an inch and a half, extending over a number of years, instead of the normal two inches and upward, is fairly satisfactory for patients under treatment or soon after the active stage of the disease. A growth of one and one-half to two inches for a similar pe-

[1] H. L. Taylor: Transactions of the American Orthopedic Association, xi., p. 197.

riod indicates that disease is arrested or is retrogressive; in other words, that the case is doing well. Very slow or absent growth indicates progressive disease or impaired vitality. Intercurrent disease or too long absence from surgical supervision is often followed by a diminution of the growth rate."

An alteration in the shape of the lower part of the face takes place in marked dorsal disease, with a facial expression which is characteristic.

FIG. 36.—Rounded Deformity from Old Disease in the Dorsal Region.

Cases in which the deformity is rapidly increasing are, as a rule, characterized by much pain.

Deformity of the chest is a constant accompaniment of dorsal Pott's disease. The vertebral column cannot give way and form an angular deformity without altering the position of the sternum and ribs. The deformity is usually a thrusting downward and forward of the sternum with a lateral flattening of the chest. In short, it results in the formation of a pigeon-breast. There may, however, be a prominence of the ribs on both sides of the sternum, where a depression of the sternum is seen. Sometimes the pigeon-breast is the first symptom to attract the attention of the parents, and for that alone the children are brought to the surgeon.

High Temperature.—Cases with Pott's disease not infrequently have an elevation of the temperature in the afternoon. This temperature is diminished or often reduced to normal in cases under bed treatment. The rise of temperature is from one to three degrees in average cases and occurs independently of abscesses. This statement rests on ten hundred and fifty observations made at the surgical out-patient department of the Children's Hospital.[1]

[1] Amer. Jour. Med. Sciences, December, 1891.

General Condition.—Pott's disease produces a more profound impression upon the general condition than do the other tuberculous joint and bone diseases. The children affected are frequently fretful and capricious, made so either by the disease and by ill-health or by injudicious petting on the part of the family. They are also often precocious and their mental development is superior to that of healthy children of the same age. They are, moreover, delicate, take cold easily, and seem especially liable to slight attacks of pneumonia. Patients with Pott's disease are of course liable to attacks of tuberculous meningitis, but the experience of the writers would lead them to believe that the liability to this was less than in hip-joint disease. Necrosis of the ribs is one of the more uncommon complications.

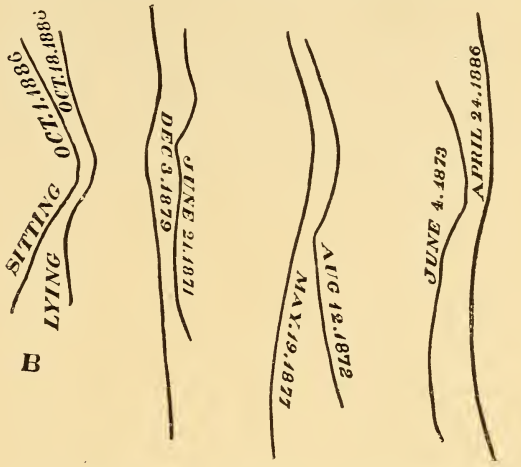


FIG. 37.—Tracings from Cases of Pott's Disease Showing the Recession of the Deformity under Mechanical Treatment.

FIG. 38.—Depression of Sternum in Dorsal Pott's Disease.

COMPLICATIONS.

Paralysis.—Partial or complete paralysis of the legs is a frequent complication of Pott's disease. It may occur in early or late, in mild or severe cases, and no apparent exciting cause can be assigned for its appearance.

The clinical picture is what one would expect from a consideration of the pathological condition; a paralysis of motion mild or severe, fol-

lowed, if the case gets worse, by more or less paralysis of sensation. The motor paralysis varies from mere muscular weakness to complete loss of power. It begins as a sense of fatigue, a dragging of the feet; then there is inability to hold one's self erect. Unless the disease is in the lumbar region, the reflexes are exaggerated, and muscular spasms may start from the least irritation; they frequently appear spontaneously. In severe cases the muscles are flaccid and the legs may be powerless. With the secondary degenerations in the cord, rigidity sets in. The bladder and rectum are paralyzed toward the end of all severe cases, and whenever the lumbar enlargement is involved; in milder cases they escape. The arms are paralyzed in certain instances of dorsal Pott's disease. Of the sensory paralysis below the lesion there is less to be said; it is apt to begin as paræsthesia; anæsthesia afterward may come on to a greater or less extent. Trophic disturbances are not to be seen unless in exceptional cases.

The wasting of the muscles and diminution of electric contractility are usually only such as disuse would cause.

In a few instances affections of the joints, supposed to be secondary to lesions of the cord, have been noted, and instances are mentioned in which herpes zoster, apparently due to the same cause, was present.

Paralysis is rarely an early symptom in Pott's disease, though it has been observed before the stage of deformity. The frequency of paralysis is indicated by the figures collected in 700 cases observed by Dollinger. Forty-one cases of paralysis were noted (5.8 per cent). In 26 of the 41 cases the disease involved the region from the third to the seventh dorsal vertebræ inclusive.

Paralysis is usually bilateral; it may, however, be unilateral, and in some unusual instances it occurs above the point of deformity. Taylor and Lovett [1] found, in an examination of 59 cases of paralysis (out of 445 cases of Pott's disease), that the location of disease was as follows: 1 cervical, 7 cervico-dorsal, 37 dorsal, 7 dorso-lumbar, 4 lumbar, 3 unclassified. The deformity was large in 20, medium in 10, small in 17 (in 12 unclassified). The paralyzed cases presented no worse deformity than that seen in average cases. In 26 the outline of the deformity was rounded and gradual; in 16 it was distinctly sharp. The paralysis occurred on the average about two years after the beginning of the disease. It came on immediately after a fall in 4 cases. The duration of the paralysis was never, in the cases reported, over three years, except in one case, when it persisted with but little improvement for six years; in 2 cases it lasted three years; in 5 cases it lasted two years. A recurrence of the paralysis was noted in 6 cases, 4 having two attacks and 2 having three. Out of 209 cases collected by Myers,

[1] Med. Rec., 1886, xxix., 699.

in 105 the paralysis accompanied disease above the eighth dorsal vertebra. Recurrence is not an unusual feature in its history.

Paralysis is not a common occurrence in Pott's disease under efficient protective treatment. Its prognosis is extremely favorable in mild cases, or in severe ones if they can be treated early. Recovery, when it occurs, is generally complete, leaving no trace of the disability of the limbs.

Abscess.—In most cases of Pott's disease, especially in those under efficient treatment, the whole course is run without any evidence of suppuration, but in others abscesses form a distressing complication.

The earlier treatment is begun and the more efficiently it is carried out, the less liable are abscesses to form; but it must not be assumed that the occurrence of abscesses is evidence of incomplete treatment. In certain cases of severe disease an abscess cannot be avoided.

The causes of the development of an abscess are the same in Pott's disease as in bone tuberculosis elsewhere. What the abscess-determining influences are, which in some instances give rise to profuse suppuration and the absence of which in other cases allows immunity, is at present conjectural. They may be supposed to be dependent on the amount of constitutional or local power of resistance on the part of the patient, the extent of the bacillary invasion, the severity of a previous injury, and the individual degree of recuperative power or of reparative tissue development. If we consider the situation of the vertebral bodies (the point of origin of abscesses)—projecting into the cavities of the thorax and abdomen, surrounded by the lungs and intestines, close to the large vessels and the œsophagus—it will seem extraordinary that the formation of an abscess does not more frequently lead to a fatal termination. In fact, however, the fluid contents of the abscesses follow in the line of least resistance, and the layers of fasciæ in most cases protect the larger cavities of the trunk from invasion; the pus generally extends to the surface at points distant from its origin, appearing in the neck, in the lumbar region, in the groin, or in Scarpa's triangle.

FIG. 39.—Diagram of Abscess from Pott's Disease.

Psoas abscess is the most common. It is very rarely met with in children unless in connection with vertebral disease, but in general it is an almost pathognomonic sign of dorsal or lumbar Pott's disease.

The abscess tends to enlarge more on its outer than on its inner side because the fascia is less resistant there. It finally reaches Poupart's ligament and bulges in the groin. The pus may, however,

FIG. 40.—Psoas Abscess.

travel as far down as the insertion of the psoas muscle. There is then a swelling both above and below Poupart's ligament, and fluctuation may be detected between the two by placing one finger above the ligament and the other below it.

Pus may find its way to the iliac fossa either from a psoas abscess or directly from the diseased bodies. At times a collection of pus will

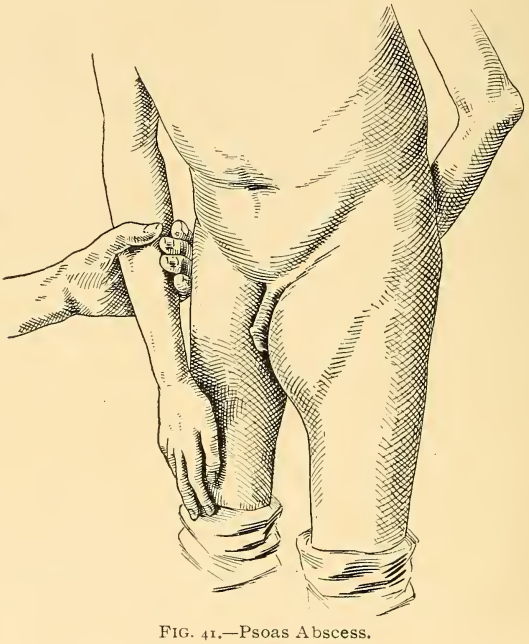


FIG. 41.—Psoas Abscess.

work over the crest of the ilium or through the sacro-sciatic foramen and point in the gluteal region.

Abscesses may accumulate in the inguinal region above Poupart's ligament, simulating hernia. Before passing down the sheath of the

psoas muscle, they may enlarge in the abdominal cavity beneath the peritoneum, constituting a layer of subperitoneal abscesses. In time these abscesses descend down the thigh, but they may remain for a long time large, threatening, abdominal tumors.

A *lumbar abscess* is the outcome of disease of the lumbar vertebræ. It appears as a swelling in the loin on one side or the other just outside the quadratus lumborum. At times it is associated with dorsal disease and not with lumbar.

FIG. 42.—Lumbar Abscess.

Abscess in *dorsal* disease may pass between the ribs and appear as a tumor on one side of the spine, or the accumulation of pus may remain in the posterior mediastinum, giving rise to cough and dyspnœa, and may be detected as an area on one side of the spine, dull to percussion.

Cervical abscess appears as a tumor at the side of the neck, simulating the ordinary deep cervical abscess, or it may appear as a bunch at the back of the pharynx, causing difficulty in breathing and swallowing. The latter is known as a *retropharyngeal* abscess.

Abscesses, however, may burst into the mouth, trachea, bronchi, mediastinum, œsophagus, or pleura. They may rupture into the intestines, bladder, vagina, rectum, or the abdominal cavity; and one case is reported in which a spinal abscess simulated a fistula in ano. Abscesses may also burst into the spinal canal or the hip-joint. Occasionally they burst in the alimentary canal, not so rarely in the lungs, and exceptionally in the peritoneum or larger vessels.

Abscesses in the lung give rise to less disturbance than would be supposed; in reality they present the rational and physical signs of a low form of localized pneumonia, of a chronic or subacute type. The bursting of an abscess into the bronchi is characterized by the discharge of a large quantity of pus, which is coughed up, the amount of dyspnœa, collapse, and danger from suffocation being dependent on the size of the abscess. The sudden discharge of pus is the indication of rupt-

ure into the œsophagus, intestines, and bladder; rupture into the vessels will necessarily be fatal. No symptoms can be relied upon to give warning of the impending danger.

The course of an abscess is toward absorption or increase. It may remain stationary in size and quiescent for a long time—a condition of

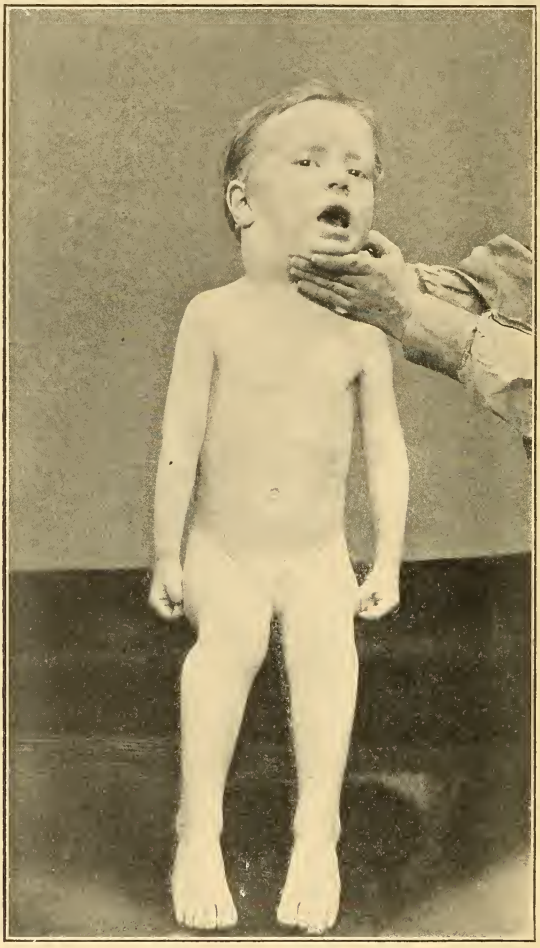


FIG. 43.—Cervical Abscess.

things which may be compatible with fair general health. Instances are not uncommon in which adults have been able to attend to active work and children to play about, although suffering from large cold abscesses.

When absorption takes place the fluid contents disappear, and the caseous and purulent detritus, if present, in all probability be-

comes encapsulated. This sometimes happens even in large psoas-abscesses.

Abscess is most frequent in disease of the lumbar region, moderately frequent in the dorsal region, and least frequent in the cervical region.[1]

DIAGNOSIS.

The ordinary clinical history of a case is of little value as an aid in establishing the presence of the disease. It may be significant enough to create a strong suspicion of the existence of vertebral disease, but without definite physical signs a diagnosis of Pott's disease cannot be made. Too much importance must not be allowed to the tendency of the parents to attribute the condition to traumatism. It should be mentioned that the absence of pain can in no way be assumed to show the absence of Pott's disease.

FIG. 44.—Retropharyngeal Abscess.

The diagnosis, then, must be made wholly from the physical examination. The chief physical signs upon which one must rely can be divided into two classes: (*a*) those occurring from bony destruction; and (*b*) those dependent upon muscular spasm.

(*a*) SIGNS DUE TO BONY DESTRUCTION.—Since these are made evident by the presence of angular deformity of the spine, which is the result of bony destruction, they are so conspicuous that they can scarcely be overlooked. And the prominence of one or more of the vertebral bodies, associated with muscular spasm, is a positive sign of the presence of the disease, unless it is the result of a fracture of the spine, or in adults the outcome of malignant disease, aneurism of the aorta, or some similar affection. In the larger number of cases, as they come to the surgeon, this bony deformity has occurred, and the diagnosis can be made at a glance; but the most important class of cases, so far as the diagnosis is concerned, are those in which bony destruction has not yet begun, and in which the need of an early diagnosis is evident, in the hope that it may lead to treatment which may be sufficient to prevent the occurrence of deformity.

(*b*) SIGNS ARISING FROM MUSCULAR SPASM.—These are:

1. Stiffness of the spine in walking and in passive manipulation.

[1] Townsend: Orth. Trans., vol. iv., 166.—Ketch: Orth. Trans., vol. iv., 200. —Dollinger: "Die Bhdlg. der Tub. Wirbelentz.," etc., Stuttgart, 1898.

2. Peculiarity of gait and attitudes assumed, according to the location of the disease.

3. Lateral deviation of the spine.[1]

For all examinations children should be stripped.

1. Muscular Stiffness.—On examining for muscular stiffness of the spine, the child is most conveniently laid face downward on a table or bed, and lifted by the feet. In a normal back the lumbar and lower dorsal spine can be markedly bent, and a general mobility of the whole column is seen. In patients in whom Pott's disease is present the region affected is held rigidly by muscular contraction when manipulation

FIG. 45.—Rigidity of Spine in Pott's Disease. (Children's Hospital Report.)

is attempted. In certain instances the erector spinæ muscles stand out like cords when the child is lifted, and it is questionable how much importance should be attributed to this sign; it occurs in cases of hip disease and in certain instances in excitable children in whom no joint disease is present. Lifting the patient by the feet in this way will show the existence of lumbar or lower dorsal rigidity, but it does not detect high dorsal Pott's disease. In lumbar Pott's disease lateral mobility of the spine, as well as antero-posterior flexibility, is lost.

2. Peculiar Gait and Attitudes.—In considering the gait as a diagnostic symptom of Pott's disease, one must be prepared to find any of the characteristic features absent. In general the walk is careful, steady, and military, and the steps are taken with such care that jars to the spine are avoided; in other instances, however, the child walks

[1] Boston Med. and Surg. Jour., October 9th, 1890.

with comparative freedom, even when the presence of the disease is manifest, and the well-known test of having the child pick up objects from the floor may fail to detect anything.

Assuming, then, the extreme importance of the early diagnosis of the disease when practicable, it becomes necessary to consider in detail the deviations from the normal signs, according to the region of the spine affected.

Cervical Pott's Disease.—The most common symptom of the disease in this region, due to muscular rigidity, is the occurrence of

Fig. 46.—Normal Flexibility of Spine. (Children's Hospital Report.)

wry-neck with stiffness of the muscles of the back and neck. This is often accompanied by distressed breathing at night and intense occipital neuralgia. The head is held sometimes in a much distorted position; the most characteristic attitude is when the chin is supported in the hand; and when the patient turns sideways to look at objects, the whole body is turned. In severe cases one notices flattening of the back of the neck, with sometimes bony deformity. When spinal disease occurs in this region the early symptoms are most often confused with sprains, muscular torticollis, and inflammation of the cervical lymphatic glands.

In disease of the upper cervical vertebræ the head, however, may

be held sharply flexed and sunk upon the chest. It may be hyperextended with the occiput resting on the upper part of the spine, or it may be held laterally bent.

From *sprains* the immediate diagnosis is almost impossible. In the early stages of sprains of the neck the head is often held stiffly and to one side; motion is resisted and is painful, muscular spasm is present, and in the case of children of unintelligent parents the history cannot be accepted as valid.

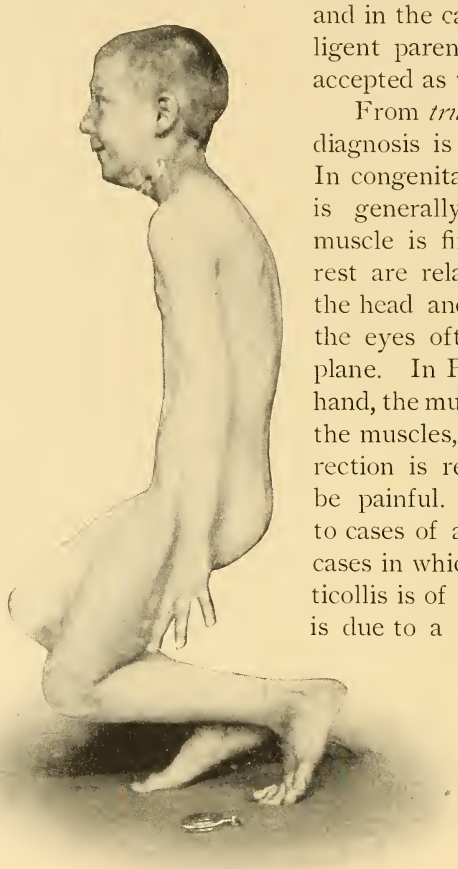


FIG. 47.—Child with Dorsal Pott's Disease Picking up Object from Floor.

From *true muscular wry-neck* the diagnosis is often extremely difficult. In congenital torticollis manipulation is generally not painful, and one muscle is firmly contracted while the rest are relaxed. In congenital cases the head and face are distorted, and the eyes often are not upon the same plane. In Pott's disease, on the other hand, the muscular fixation involves all the muscles, and movement in any direction is resisted, and is more apt to be painful. This applies fairly well to cases of anterior wry-neck; but in cases in which the true muscular torticollis is of the posterior variety, and is due to a contraction of the deeper muscles, the diagnosis is much more difficult, for no one muscle is contracted and movement is limited by a general muscular resistance.

The differential diagnosis can be most easily made by putting the patient to bed and seeing if the application of extension is sufficient to overcome the distortion, as it will do in the course of a few days if due to Pott's disease. *Rheumatic torticollis* simulates cervical Pott's disease so closely that the physical signs are not sufficient at first to differentiate the affections.

Inflammation of the lymphatic glands of the neck may give rise to a position of the head simulating wry-neck, associated with muscular spasm.

Upper Dorsal Pott's Disease.—In this region detection is the most easy because any bony destruction at once results in angular deformity, on account of the posterior curve of the spine in this part, and it is on this deformity that one must depend rather than on symptoms due to muscular stiffness.

The shoulders are, however, held high and squarely, the gait is military and careful, and lateral deviation is almost certainly present. In Pott's disease, paralysis may exceptionally be the first perceptible symptom.

From *round shoulders,* Pott's disease is generally to be distinguished

Fig. 48.—Normal Child Picking up Object from Floor.

by the fact that in the former the spine is flexible and the deformity rounded and not angular. The distinction is generally easily made.

Lumbar Pott's Disease.—Vertebral disease in this region of the spine is difficult of detection on account of the anterior curve of the spine in the lumbar region, so that in any moderate amount of destruction of the lumbar vertebral bodies no posterior angular curvature is developed, and it is only in the later stages of the disease that any angularity becomes prominent. The occurrence of deformity is preceded by a flattening of the lumbar curve. The attitude is that of lordosis, which in some cases becomes very marked; the gait is military and careful, and lateral deviation is generally present, sometimes to a very marked degree. It is in this region of the spine that it is most conspicuous.

In many instances of lumbar Pott's disease the first noticeable symptom is a limp, which is due to unilateral psoas contraction, the result perhaps of abscess or perhaps only of psoas irritability. Psoas contraction must be set down as one of the common symptoms of lumbar Pott's disease. If the child is laid on its face and an attempt is made to flex the lumbar spine, it is found to be entirely rigid. Any attempt to hyperextend the leg in this position leads to the detection of the slightest psoas irritability.

Lumbar Pott's disease is occasionally mistaken for single or double hip disease, or is regarded as a rhachitic curvature.

The differential diagnosis between lumbar Pott's disease and *hip*

FIG. 49.—Attitude Assumed in Dorsal Pott's Disease when Rising from Floor.

disease is at times difficult, although it is not generally considered so. When the hip symptoms are due to Pott's disease and are caused by psoas irritability, the restriction of motion in the hip is simply in the loss of hyperextension, while abduction and internal rotation are free and not affected. This limitation of motion in only one direction is generally sufficient, in connection with the other symptoms, to establish

the presence of Pott's disease. On the other hand, in some cases the limitation of the hip's motion is in all directions, and simulates very closely the limitation of true hip disease.

Another element which leads to the confusion of the two affections is the rigidity of the lumbar spine which often occurs as an accompaniment of acute hip disease. If a child with hip disease is laid upon its face, and an attempt made to flex the lumbar spine by lifting the feet from the table, the irritability of all the muscles is so great that often the lumbar spine will appear to be completely rigid, and only a very careful examination will show that this is secondary to the hip disease.

Rhachitic deformity of the spine is a posterior curvature often so sharp as to be angular. It occurs at the junction of the dorsal and the lumbar regions. This junction is also a frequent site of Pott's disease. Muscular stiffness may not be present.

FIG. 50.—Examination for Psoas Contraction. (Children's Hospital Report.)

Rhachitic curvature of the spine is characterized by persistent stiffness in most cases, so that if the child is laid upon its face, and an attempt is made to flex the spine, the curve is not obliterated. The symptoms, therefore, are the same that would be presented by Pott's disease occurring under the same conditions, and much dependence must be placed upon the coexistence of rickets. It is often of use to treat such cases by rest on a frame, and if the curve is rhachitic, mobility will be restored to the back within the course of a few months.

The Diagnosis of Abscess.—The diagnosis of a well-developed abscess in Pott's disease rarely presents any difficulty, but in certain instances their occurrence is attended with peculiar symptoms which may give rise to some obscurity. In the cervical region the most common seat of abscess formation is in the back wall of the pharynx, where it often persists for some time unrecognized, giving rise to a peculiar series of respiratory symptoms. The pharyngeal wall is pushed for-

ward, and the child breathes at night with a peculiar snoring respiration, which is to a certain extent characteristic. There is some difficulty in swallowing food; the pain is apt to be severe; and occasionally a swelling extends so much to the side as to be noticeable at the side of the neck. The finger introduced into the mouth comes upon a projecting swelling of the back of the pharynx, which is characteristic and not to be mistaken.

In the dorsal and lumbar region the abscesses point for the most part in the loin, or follow down the course of the psoas muscle to appear in the upper part of the thigh or groin. Appearing in the back, the abscess is not likely to be mistaken for anything unless for an abscess of the back muscles or a lipoma.

Psoas abscess causes limitation of hyperextension of the hip, and therefore a limp. In the iliac fossa a resistant or fluctuating tumor is to be felt. When abscess is present, if the child is laid on the face, hyperextension of the hip on the affected side will be found to be limited.

The Diagnosis of Paralysis.—Paralysis in Pott's disease, although ordinarily one of the later symptoms, may occasionally precede the deformity and be the first sign of the presence of vertebral disease. Such cases are not so rare that they should be overlooked. The occurrence of myelitis in a young child should be considered as extremely suspicious, and as being more likely due to Pott's disease than to any other cause, even if the signs of vertebral disease are obscure or apparently absent. In general the paralysis is preceded by a stage of the disease in which pain is much increased. Ordinarily one of the first demonstrable signs is an increase of the patella reflexes, with perhaps ankle clonus.

Sprain.—It is difficult at times to differentiate a sprain of the vertebral column from Pott's disease. After a fall in which the back has been wrenched, a child begins to walk stiffly and to complain of pain in the back and perhaps in the legs. Attitudes characteristic of Pott's disease are assumed, the trunk is supported with the hands upon the thighs, the back is kept stiff in stooping, and passive manipulation shows that muscular rigidity is present. At an early stage a diagnosis is sometimes clearly impossible. But in sprains of the back the tendency is to a rapid recovery under proper conditions, and the result establishes the diagnosis. Severe sprains of the back are comparatively rare in childhood, but in adult males engaged in laborious occupation cases of strain are more common than cases of Pott's disease. The diagnosis is one which should be made in childhood with very great reserve.

Rotary lateral curvature of the spine is an entirely different affection from Pott's disease. It is not the result of a tuberculous destruction of bone, but is the result of a distorted and abnormal process of

growth. It is characterized not by an angular projection of the spine backward, but by a gradual curve of the spine laterally with a rotation of the vertebral column on its long axis. Pain is not present, and the recognition of the affection is generally due to an alteration in the outlines of the trunk and a prominence of the shoulder or hip.

In most cases the diagnosis is not at all obscure. But in the course of Pott's disease at an early stage a lateral deviation may be present, which may be mistaken for lateral curvature. On a careful examination it will, however, be found that a stiffness of the back is present which is never seen at an early stage of lateral curvature. In some instances careful and repeated examinations are needed to establish a positive opinion.

A lateral deviation takes place also sometimes in old cases of Pott's disease in connection with an old kyphotic curve destruction of bone greater at one side than at the other.

Hyperæsthetic spine, also termed the hysterical spine and the neuromimetic spine, is characterized by tenderness in certain portions of the back, sometimes accompanied by pain or ache. This condition is more common in neurotic persons, but may be seen in others who have been suffering from nervous exhaustion from any cause. It generally follows some slight or severe accident and as a rule occurs in persons with weak back muscles. The tenderness may be intense and manifestly exaggerated, or it may be only slight and confined to small spots in the lower cervical and upper dorsal or in the upper lumbar region. As a rule, no real stiffness in the back is present, but in severe cases, or in cases which have remained in bed for some time, muscular stiffness may be present. This condition is sometimes seen after railway accidents. In the cases that are termed "railway spine," abnormal projection or deformity in the spine does not exist, although lax ligaments and weak muscles permit a flexed condition of the spinal column in standing, which may make one or two vertebræ unduly prominent as the patient stands erect, but this prominence disappears in recumbency. Referred pains, or the attitude and gait characteristic of Pott's disease, are absent. A hyperæsthetic spine occurs in adults, and especially in growing young girls; it may exceptionally be seen in children.

Malignant disease of the spine presents, when a projection is found, a more rounded and less sharp projection than is seen in the beginning of caries. Carcinoma of the spine is usually secondary. The symptoms, however — pseudo-neuralgias, paresis, paralysis, and muscular stiffness—are the same in both, and sometimes only a conjectural diagnosis can be made. Sarcoma of the spine is very rare in childhood.

Much the same may be said of the curvatures of the spine caused by *aneurism*, except that the diagnosis is usually made by auscultation or by the rational symptoms before the spine is noticeably affected.

Tumors pressing on the spinal cord may cause stiffness of the back

and pain referred to the peripheral ends of the nerves. Angular deformity, however, is absent, and the symptoms of nervous disturbance predominate over the ordinary ones of Pott's disease.

Osteomyelitis of the spine may be secondary or primary. The transverse and articular processes as well as the vertebral bodies may be affected, and tenderness is present at the seat of disease. Suppuration elsewhere occurs in sixty per cent of all cases. There is much constitutional disturbance, fever is high, and the course rapid. Œdema of the affected parts appears early; abscesses of a very acute and extensive character as well as paralysis are other early features. The formation of a kyphus of any extent is unusual.

Spondylitis deformans of the spine is an affection most frequent in adult life, characterized on superficial examination by stiffness and some arching of the spine; there are usually little muscular spasm and no unusual projection of the spinous processes; in some instances the ribs are ankylosed to the spine, so that no expansion of the chest is possible. Stiffness of the back is present, but the whole spine is rigid and other joints may be involved. These cases may occur in connection with gonorrhœa. Patients suffering from this affection may have neuralgic or pseudo-neuralgic pains of the nerves issuing from the spine at the affected part.

Spondylolisthesis, or dislocation of one of the lumbar vertebræ, may cause pain, lordosis, and peculiarity of gait and posture. There is no characteristic kyphus and the diagnostic signs of spondylolisthesis will establish its existence.

With regard to the symptoms of *sacro-iliac* disease, *perinephritis*, and *appendicitis*, it may be said that a mistake in diagnosis may happen, but that ordinarily there is no obscurity. It should, however, be borne in mind that in appendicitis and in perinephritis, when an abscess is present, a contraction of the thigh may occur, resembling that seen in psoas abscess. The absence of a projection or irregularity of the back, and the power of muscular movement of the back in these cases, will help to establish the fact that they are not due to disease of the spine.

Skiagrams in early cases of Pott's disease rarely aid in the diagnosis, but when marked osseous change has taken place the fact may be seen in certain regions of the back.

PROGNOSIS.

Pott's disease will always be regarded as one of the most formidable of diseases; its long course, the deformity entailed, the severity of the complications, and the occasional termination in death give both to the surgeon and to the non-professional public a natural dread of the affection. These inferences are, however, drawn from the severer cases,

and facts show that the disease has a tendency to spontaneous recovery, that in certain parts of the spine deformity can be prevented, and that in few affections does the work of the surgeon give greater relief than in Pott's disease.

Mortality.—No statistics of value exist as to the percentage of mortality and recovery.

The occurrence of severe pain, fever, and rapid increase of the deformity are unfavorable from a prognostic point of view. The general condition of the patient and the family history are of importance in the prognosis. The occurrence of paralysis does not affect the prognosis unfavorably. The occurrence of abscess makes the prognosis slightly less favorable, because abscess accompanies the severer cases.

Forty-nine cases of psoas abscess operated on at the Children's Hospital in the decade ending in 1900 were investigated as to end results by one of the writers. Thirty-five per cent were known to have died and 53 per cent to be alive shortly after the close of the decade. Of cases operated on in the first five years 50 per cent were dead, and of cases in the last five years 26 per cent had died.

The percentage of recovery, however, in patients under better hygienic conditions than hospital patients is more favorable.

The tendency of the deformity is to spontaneous increase, and this is specially marked in the upper dorsal region. Instances of arrest without marked deformity are not so very rare in upper cervical disease and in lumbar disease, but in the upper and middle dorsal regions the tendency is for an increase of the deformity proportionate to the extent of the disease. In many cases some arrest of the growth of the whole child takes place apart from the loss of vertebral substance. The cure from Pott's disease may be so complete as to permit normal childbirth, provided no distortion of the pelvis has taken place.[1]

No reliable statistics exist as to the amount of time necessary to establish a cure in Pott's disease. The disease varies greatly as to its self-limitation in individuals, and according to the situation and extent of the disease. Necessarily there will be a difference in individual cases in the result of treatment.

It may be said that, as the bodies in the cervical region are smaller than those in the lumbar, the time required for self-limitation here is shorter than in the lumbar region. In the latter region, also, the superincumbent weight is a more important factor than in the upper part of the spine.

The occurrence of bony formation firm enough to support the column in its weight-bearing function must be a process requiring a long time for its completion, to judge from it as observed elsewhere; and nowhere is protection more urgently demanded during convalescence

[1] Trans. Amer. Orth. Assn., vol. iv.

than in the vertebral column. This is especially true in growing children. Cases of supposed cure of Pott's disease have redeveloped symptoms at the period of rapid growth at the approach of puberty. It should especially be borne in mind that protection to the spine may be needed at this period.

TREATMENT.

This varies according to the stage and condition of the pathological process.

When the destructive ostitis is acute and extensive the affected bone should be protected from all jar and pressure, both that due to superimposed weight and attitude. When cicatrization has begun the spine should be protected so that activity necessary for health may not cause injury in the imperfectly healed bone structure.

Protection is necessary until the previously inflamed bone has become cicatrized so thoroughly as to withstand without injury jar and superimposed pressure.

A growing spinal column, even if the vertebræ have recovered from caries, may need support to prevent an increase of curvature by abnormal growth.

Treatment, therefore, is different in the acute, the subacute, and the convalescent stages. In the acute stage recumbency is the most efficient method. In the subacute and convalescent stage ambulatory treatment with more or less efficient spinal protection is advisable.

Treatment by Recumbency

If the patient lies upon his back or upon his face on a hard surface, there is no superincumbent weight pressing upon any portion of the spine. If the patient lies upon his back upon a spring-bed, and the bed

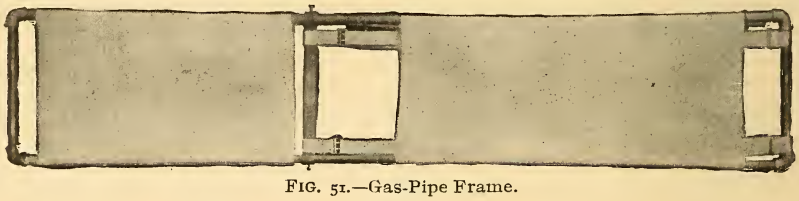


Fig. 51.—Gas-Pipe Frame.

sags, the spine is of course bent, and pressure upon the vertebræ, proportional in amount to the extent of the curve, results.

If treatment by recumbency is to be adopted, it is not sufficient simply to place the child in bed. Sagging of the mattress, moving of the patient from side to side, twisting and turning are all injurious, in that they cause motion between the vertebræ and change interarticular pressure, both of which are undesirable.

It is necessary that the child should be fixed in a suitable position in bed. This can be done by securing the child in such a manner that

the vertebral column at the seat of disease is arched forward, diminishing the interarticular pressure. The simplest way of doing this is by means of a frame.

The rectangular bed frame (Chapter XXI., **9**) consists of a stretcher of heavy cloth attached to a rectangular gas-pipe frame.

The child lying upon this frame can be secured by means of straps across the shoulders and pelvis and knees, and can be carried about

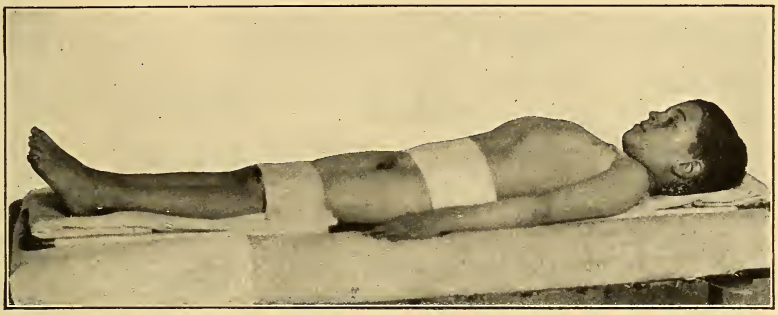


FIG. 52.—Method of Securing Child to Bed Frame for Recumbent Treatment of Dorsal Pott's Disease.

without jar. When the frame is placed upon the bed, the cloth covering is no more uncomfortable than the surface of the bed.

But simple recumbency is not alone sufficient to promote cicatricial ostitis. The removal of intervertebral pressure is also necessary. This is to be accomplished by arching the spinal column forward at the point of the kyphotic curve. When the cicatrization has not progressed

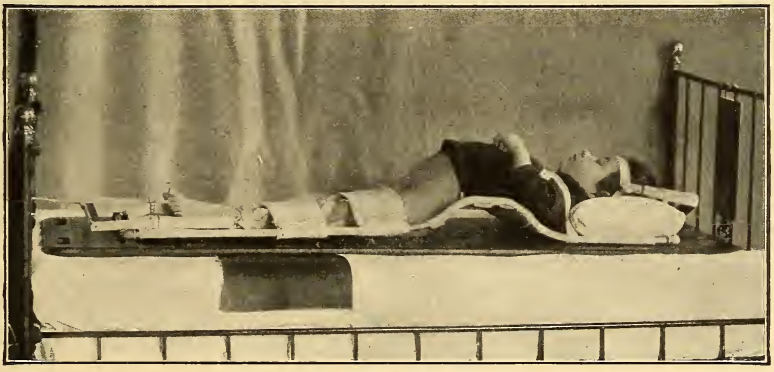


FIG. 53.—Gas-Pipe Silva Frame.

so far as to produce ankylosis, correction (partial or complete) of the curve can be effected by placing under the curve of the child lying upon the back a firm pad, pressing upon each side of the spinous process, and sufficiently high to press this part upward while the rest of the spinal column drops back by its own weight. The pads can be furnished by properly folded sheets or towels, by felt padding, or by a

plaster-of-Paris back moulded to a corrected position of the spine, or by arching the frame at a desired point, as has been suggested by Silva and Whitman.[1] This holds the spine hyperextended throughout its length. In this way greater separation at the diseased region is obtained perhaps more easily than on the ordinary frame. The ordinary frame, however, properly padded, answers every purpose.

A child undergoing treatment on the frame should be turned once a day to have the back washed, rubbed with alcohol, and powdered. It is important that there should be no pads in the median line immedi-

FIG. 54.—Traction in Cervical Caries. (Children's Hospital Report.)

ately above or below the deformity, but that the pads should lie entirely outside of the line of the spinous processes. To secure better fixation it may at times be necessary to place pads under the lumbar region.

In cervical caries head traction in a recumbent position will be found of use in cases of torticollis; and in severe neuralgia from cervical caries the relief afforded is often very marked. Traction can be furnished by means of a head sling passing over the forehead and occiput, which is attached to a weight and pulley running over the head of the bed or to the head of the frame. The counter pull may be furnished by the weight of the body in case the head of the bed is raised, by a downward pull upon the trunk through a waist band, or by means of traction applied to the limbs.

Treatment by recumbency will be found of service, either alone or in conjunction with other methods, in cases with acute symptoms, in cases of severe cervical disease, in cases with marked lateral deviation

[1] Whitman's "Orth. Surg.," 2d ed., p. 91.

of the spine, in paralysis, in cases of psoas contraction and abscess, in cases which do not progress well under ambulatory treatment and which lose flesh and strength, and in very small children in whom the difficulty of fixing the spine by apparatus is great.

Patients who have been suffering will often be found to gain flesh after the relief afforded by recumbency, though the muscles in the limbs diminish in size.

Treatment by recumbency, if used, should be thorough. Half measures have the evils of the imprisonment without the benefit of fixation. The limit of its usefulness is usually marked by the restlessness of the patient. In children the irksomeness of the confinement is borne readily; but in adults the imprisonment constitutes a serious obstacle to the employment of the method.

The objections to treatment by recumbency are evident. Pott's disease is a tuberculous affection and close confinement is injurious to

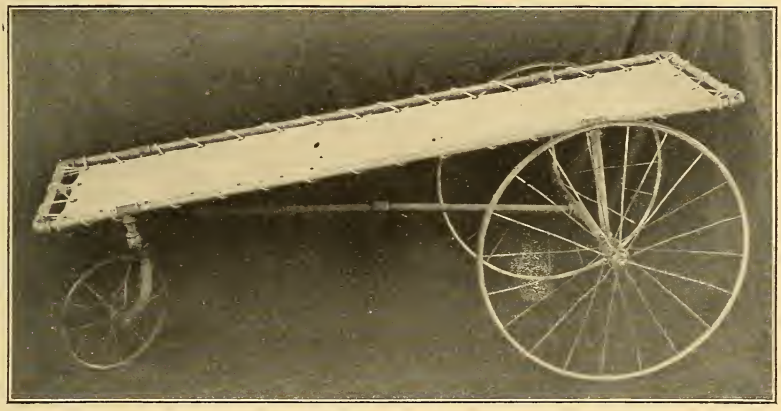


FIG. 55.—Ward Carriage for Recumbent Treatment of Pott's Disease.

patients with a tuberculous taint. Patients of this sort need all possible help from fresh air and exercise, and the method of treatment by recumbency for years, formerly the only thorough method possible, is not now regarded as necessary in all cases. It must be remembered that all apparatus is necessarily imperfect from a mechanical point of view and must fail in wholly relieving the diseased vertebræ of their weight-bearing function, so that within its limitations recumbency is to be recognized as mechanically the most efficient mode of treatment and the least likely to encourage deformity.

AMBULATORY TREATMENT.

Treatment by Plaster Jackets.—The purpose of the treatment by plaster jackets is to fix the spine so firmly that there will be no injury to the affected vertebræ from the jar incident to locomotion.

Plaster jackets (Chapter XXI., **1**) are made by applying successive layers of properly prepared bandages to the patient's trunk, which has been placed in a suitable position.

The patient during the application of a plaster jacket is either upright or recumbent (on back or face), with or without a suspension or a traction pull. The application of the jacket by suspending the patient by the head and arms was the method introduced by Sayre, and has the advantage of ready application and has been of great benefit in curing a large number of patients unrelieved by former methods.

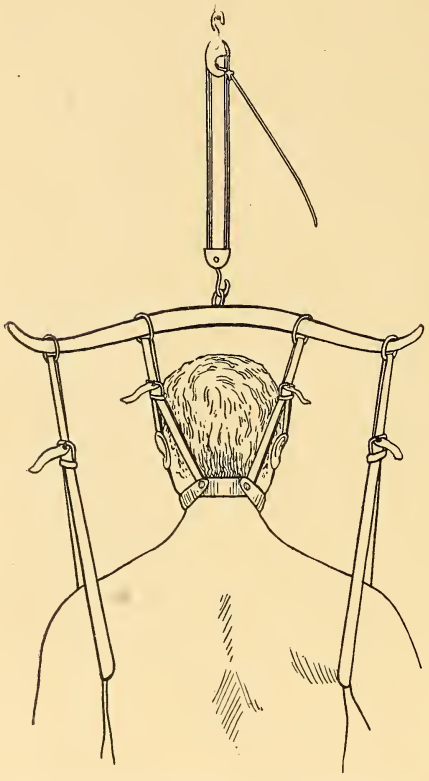


FIG. 56.—Sayre Headpiece for Suspension in Pott's Disease.

APPLICATION OF JACKET WITH THE PATIENT SUSPENDED.—Suspending a healthy person by the head diminishes the physiological curves (cervical and lumbar lordosis, dorsal kyphosis), and the spine becomes straight so far as its formation will allow.

In suspension, in old Pott's disease, it is only the physiological curves which are obliterated;[1] the sharp kyphosis is held too firmly by adhesions to permit correction. In earlier cases the intervertebral pressure is, in a measure, diminished at the point of disease by suspension; but suspension does not cause a disappearance of the sharp angular projections at the point of disease, although the kyphus is diminished.

The undoubted beneficial effect of a plaster jacket is due to its service as a fixation support in an improved position, although it was originally supposed that a jacket could be applied so as to serve as a means for holding the diseased vertebræ apart, *i.e.*, as a means of distraction. The treatment by plaster jackets requires care, for a poor jacket does harm rather than good by deceiving the physician and the patient. For the proper applying of plaster jackets, moreover, a careful attention to detail is necessary.

The patient's clothes are removed and a thin, tightly fitting under-

[1] Anders: Archiv f. klinische Chirurgie, 1889, iii., p. 558.

shirt is applied, put on so as to present no wrinkles. The patient is thickly padded by felt or sheet-wadding pads over the pelvis and two thick felt pads are placed longitudinally at the sides of the kyphus. The patient is then suspended; the head is secured in a sling, which is attached to a strong cord playing in a pulley, or series of pulleys, fastened to a point above the patient's head. An assistant pulling on the cord raises the patient so that the heels are free from the floor. It is desirable to diminish the strain upon the neck, and padded loops connected with the bar, which is raised by the cord and pulley, can be

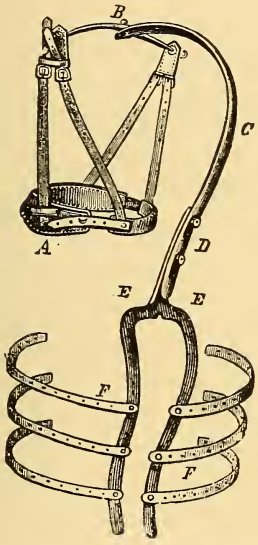


FIG. 57.—Jury-mast Before Incorporation.

FIG. 58.—Jury-mast and Plaster Jacket.

passed under each axilla, or handles may be held in each hand, connected with cords which play over pulleys.[1]

The bandages are then wound smoothly around the patient. If the plaster is fresh and of the best quality, it should harden in five minutes. The hardening can be hastened by putting salt or alum in the water, but this makes the plaster somewhat more brittle. After the plaster is hard or nearly hard, the patient is to be placed on a soft flat surface, care being taken not to crack the plaster in so doing. The edges of the jacket are smoothed down and cut off if they press uncomfortably on the thighs or axillæ.

It is important that the jacket should be strong in front as well as behind, and should be wound as high as possible in front, in order to

[1] A. Thorndike: "Comparison of Different Methods." Am. Journ. Orth. Surg., vol. ii., 1.

prevent the spinal column from falling forward. If the jacket becomes broken or softened, it should be removed and another applied.

If the disease is in the cervical region, the plaster bandages can be carried up around the back of the head and neck and under the chin, leaving the face and upper part of the head exposed, and so fixation and support may be obtained in that part of the vertebral column. This method of fixation has certain manifest disadvantages in lack of cleanliness, clumsiness, and unsightliness, but it is thorough and furnishes an excellent support and is by no means uncomfortable for the patient.

It is more efficient than the head sling attached to a bent rod extending above the head and incorporated below into the plaster jacket—

FIG. 59.—Paper Jacket. (Children's Hospital Report.)

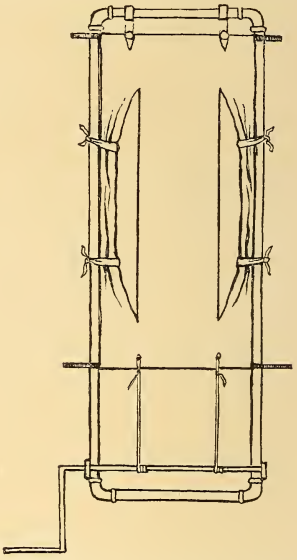


FIG. 60.—Hammock Frame for the Application of Jackets during Recumbency on the Face. Ready for use.

the "jury mast" devised by Sayre. The required degree of suspension varies with the seat of the disease and the firmness of the curve; but complete suspension is rarely necessary in cervical and dorsal cases, as removal of the superimposed weight can be accomplished without this.

APPLICATION DURING RECUMBENCY ON THE FACE.—The patient is laid face downward with the arms above the head on a hammock, which consists of a stout cloth a little wider than the child, stretched over the ends of a rectangular gas-pipe frame. One end of this cloth is attached to the upper end of the frame and does not move. The other end is attached to a movable bar connected with the other end of the frame by a rope. By a ratchet this bar can be pulled upon and the tension of the cloth regulated. The hammock may be made very tight or allowed

to sag to any extent. In this way hyperextension of the spine may be produced as desired.

The hammock cloth is cut along the sides of the child's body longitudinally and the parts not under the child's body are drawn aside and fastened or cut away. The plaster rollers are then applied, including both child and hammock.

Instead of the stretched hammock cloth, the patient may be placed on two pieces of stout webbing stretched along the length of a rectangular frame. These should be placed sufficiently near together to support the trunk without pressure upon the chest. Cross straps of webbing are necessary at the hips and shoulders when the jacket is applied.

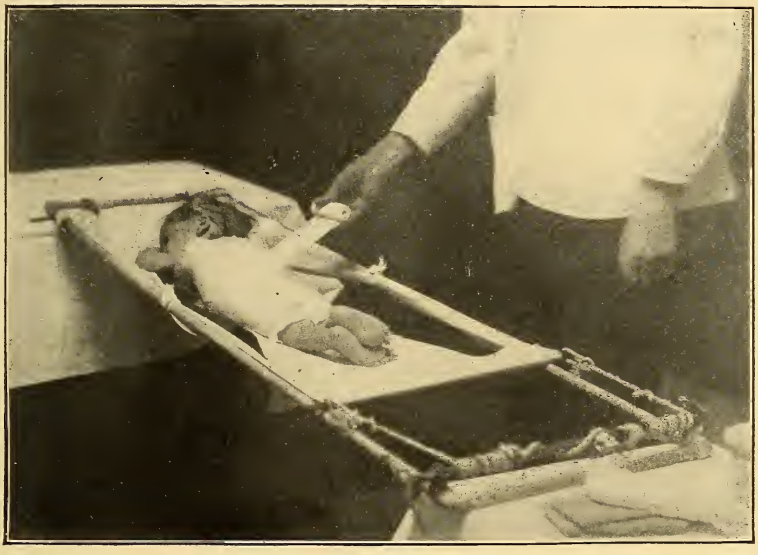


FIG. 61.—Method of Applying a Plaster Jacket in Recumbency, on the Hammock Frame.

The webbing straps are untied and patient released, after which they are pulled out.

This method, as has been demonstrated by Brackett,[1] is serviceable for lumbar and low dorsal disease, but is not as satisfactory in cases attacking the spinal column higher up, requiring close apposition of the bandages in the upper part of the front of the chest.

This difficulty and the necessity of raising the shoulders and hyperextending the spine above the diseased region can be met by the use of an appliance devised by one of the writers[2] (Fig. 66).

The apparatus consists of an oblong gas-pipe frame of the ordinary pattern. Fastened to this near the middle and hinged so as to be

[1] Trans. Am. Orthop. Assn., vol. viii., p. 160.

[2] Lovett: American Medicine, vol. iv., No. 10, p. 373.

raised to any degree is another section of gas-pipe lying on the frame proper and of the same shape and size as the upper half of the frame. To this movable section is fastened at right angles to it and movable on it a gas-pipe bridge, rising about eighteen inches from the movable section.

The patient lies face downward on two straps of webbing, lying one over the other, run from each of the buckles at the bottom of the frame. The lower pair of these strips are tightly drawn and run to the buckles

FIG. 62.—Plaster Jacket. Front view.

FIG. 63.—Plaster Jacket. Back view.

at the end of the movable section. The upper pair are loosely fastened to the bridge over the movable section.

The patient should be placed in such a way that the seat of disease comes opposite the hinge where the movable piece is attached, and the head and pelvic webbing supports are adjusted to their proper places.

The deformity must be very heavily padded by thick felt pads placed on each side of it. The jacket is then applied in the usual way up to and only as far as the level of the apex of the deformity and allowed to harden. After the plaster has hardened, a piece of webbing or stout cotton bandage running from side to side of the main frame (not attached to the movable section) is passed over the upper back edge of

the jacket and when this is fastened in place the movable section of the frame is lifted until the desired correction is obtained at the seat of the deformity. When the desired point is reached the movable section is fastened in position and a few turns made with a plaster bandage, going up two or three inches above the deformity. Then the straps running to the end of the movable section which have been the chief hyperextending force are unbuckled and turned up over the bridge, and the patient remains suspended by the straps running from

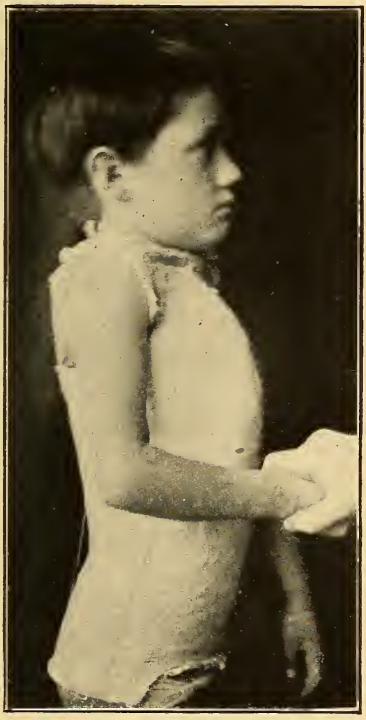


FIG. 64.—Plaster Jacket. Side view.

FIG. 65.—Plaster Jacket and Headpiece. (Wullstein.)

the bottom of the frame to the bridge. These are closely applied to the front of the chest and shoulders and permit the upper part of the jacket to be firmly applied around the sternum, upper ribs, and front of the shoulders, holding the chest well back.

When the plaster has hardened the webbing strips are unbuckled and the patient is removed from the frame. The webbing strips are easily pulled out from under the jacket and are used again.

If it is desirable to diminish lumbar lordosis, the thighs should be flexed on the body as the patient lies on the face.

APPLICATION OF A JACKET WITH THE PATIENT PLACED UPON THE BACK.—In applying a jacket with the patient lying upon the face some

compression of the chest and flattening of the abdomen take place. To avoid this, a jacket can be applied with the patient placed upon his back. If this were done with the patient lying upon a stretched sheet, the sagging of the material would prevent the necessary hyperextension of the spine.

To obviate this, an appliance devised by Metzger and modified by Goldthwait, Brackett, and R. T. Taylor, will be found of assistance.

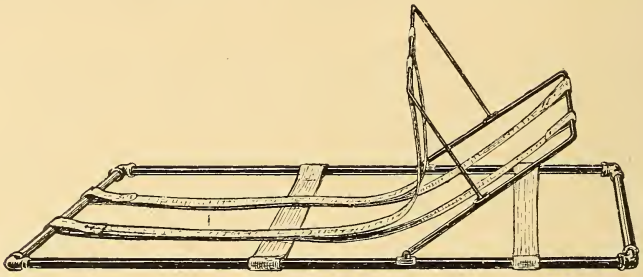


FIG. 66.—Frame with Movable Section for Application of Plaster Jackets.

An upright steel rod is arranged with a forked top on which can be placed two attachable pad plates. The rod fits in a stand and can be raised or lowered by means of a screw. If the patient is made to lie in

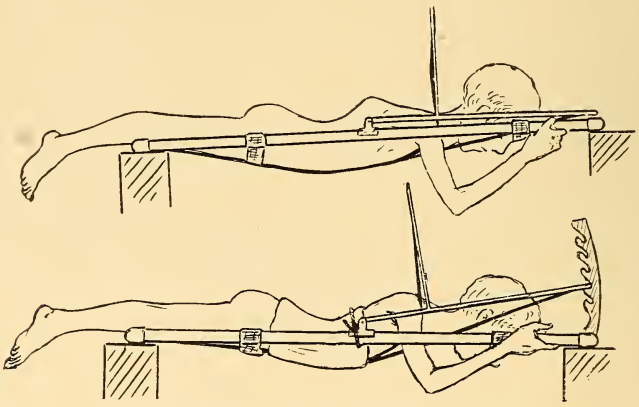


FIG. 67.—Frame with Movable Piece in Use.

such a way that, while the head, shoulders, and pelvis are supported the kyphus rests upon the pad plates, a hyperextending force is exerted on the kyphus. As the rod bearing the pad plates is raised or lowered, the pressure on the kyphus is increased or diminished. Any desired amount of hyperextension of the spine can be furnished.

Exaggerated lordosis can be prevented by flexing the thighs.

Brackett has attached the upright rod to a frame, such as is used in the hammock application of jackets.

Goldthwait[1] and R. T. Taylor have employed the principle by means of two movable stands, the former employing two parallel steel rods connecting the uprights as a support to the lower part of the back, which are removed after the jacket has hardened.

R. T. Taylor[2] has combined the arrangement with a mechanism for

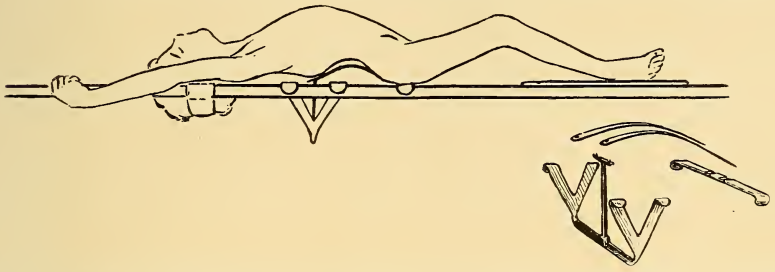


FIG. 68.—Frame for Applying Jacket with Patient Recumbent upon the Back. (Metzger-Goldthwait.)

a pull and a counter-pull. The jacket is applied in the usual way and the patient placed in the desired position.

JACKETS APPLIED WITH THE PATIENT SITTING.—The patient may be seated during the application of the jacket if it is desired to prevent lordosis in the lumbar region.

In disease of the lumbar region, since lordosis is desirable to sepa-

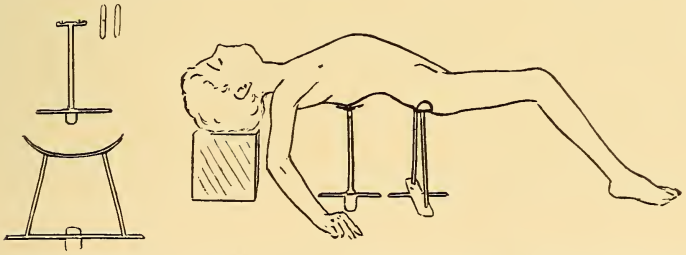


FIG. 69.—Portable Frame for Applying Plaster Jacket. (Metzger-Goldthwait.)

rate the lumbar vertebræ, suspension is not necessary. The jacket can be applied with the patient steadied and the back arched forward to secure exaggerated lordosis.

R. T. Taylor[3] has applied jackets for disease of the spine with the patient seated, using an arrangement which can be readily understood by the accompanying illustration (Fig. 70).

In adult cases of caries of the spine in the upper dorsal or cervical regions with slight kyphus, jackets can be applied with the patients seated, with the slight correction afforded by head-sling traction.

[1] Trans. Am. Orth. Assn., xi., 89.

[2] Johns Hopkins Bulletin, xii., 119.

[3] Johns Hopkins Bulletin, February, 1895, No. 45. Trans. Am. Orth. Assn., vol. xii., p. 119.

It is desirable that the surgeon should familiarize himself with the application of plaster jackets by the different methods mentioned, as it will be found that they are of assistance in different cases. Frightened children are less alarmed if placed upon a hammock than if suspended. A jacket applied with the patient placed upon a hammock is useful in low dorsal caries, but is less satisfactory in mid or upper dorsal caries. By the aid of the correcting appliance an efficient jacket can be applied in upper dorsal caries with the patient prone. A jacket where especial attention is needed in front is thus readily applied with the patient lying upon the face. Where hyperextension is needed it can be accomplished best by means of the apparatus described for application of the jacket in back recumbency. The seated position is most convenient for the patient; for simple cases with slight deformity, where much hyperextension is not needed and where the head is to be included in the jacket, suspension with the patient upright will be found the most satisfactory method.

It is sometimes the case that a jacket may be applied which appar-

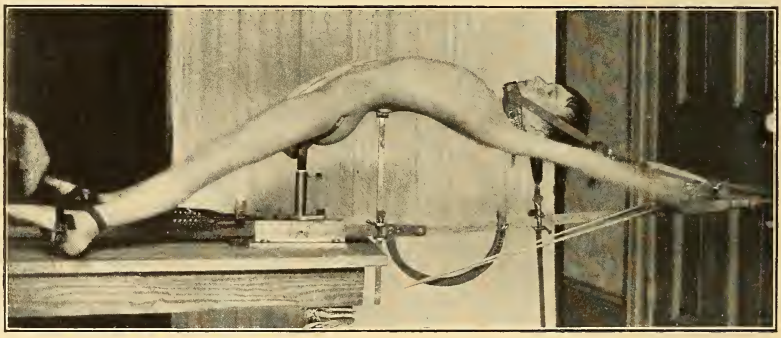


FIG. 70.—Child in Recumbent Kyphotone Ready for Application of Jacket. (R. T. Taylor.)

ently is furnishing satisfactory support, while the surgeon may wish to determine the exact amount and seat of efficient pressure. A simple method of determining this, without injury to the jacket, has been employed by Dr. A. Thorndike. A narrow longitudinal slit is cut for a sufficient distance in the back of the jacket, which is made thick for the purpose, and the position of the spine held in the jacket determined by taking a tracing of the spinous processes through the slit.[1]

The most acceptable form of permanent jacket is one applied over a seamless woven shirt. These shirts are made very long and reach the knees; one of them is put on the patient and the jacket applied over it. The lower part of the shirt is then turned up over the outside of the jacket and reaches to the top of it. It is there stitched to the upper part of the shirt along the upper edge of the jacket. This, how-

[1] Am. Journ. of Orth. Surgery, ii., 2.

ever, is not done until the jacket has been removed, by splitting it down the front and gently springing it open. The edges of the cut are stitched with leather and a row of hooks is provided on each side with which to lace it together. A jacket is thus provided, which is covered inside and outside with soft woollen material, which can be removed for purposes of cleanliness and reapplied to the patient, who should be, of course, suspended or laid on the face for each reapplication.

Removable Jackets.—After a jacket has been applied by any one of these methods, it may be converted into a removable jacket. Removable jackets are not, however, such efficient supports as fixed jackets during the acute stage of the disease. They are, as a rule, to be used in convalescent cases, in exceptional cases in the acute stage when the skin is very sensitive and requires bathing, when sloughs or excoriations are present, and in similar conditions.

As a substitute for plaster jackets, corsets are made of leather (Chapter XXI., **3**), felt, wood, aluminum, celluloid (Chapter XXI., **2**), papier-maché, silicate of potash, etc. The plaster jacket, which is applied in the usual way, is removed with care so as to preserve its shape. A cast of plaster of Paris is taken from the jacket, and on this as a form a corset is made of leather (which when wet can be stretched tightly over the form). After the plaster jacket has become hard, it can be split and furnished with eyelets and lacings; it can then be applied on the patient, who is suspended, as in the application of a plaster jacket. Rawhide stretched over a cast, thoroughly dried and left until hardened, furnishes a corset which is both light and firm. The process of manufacture requires attention and detail. The same is true of a jacket made of celluloid. Both of these corsets curl unless equally dried, before using, on the inner and outer side.

In the upper dorsal and cervical region it is necessary either to add to the plaster jacket an appliance for securing the head (the varieties of which will be mentioned later), or to carry the plaster jacket over the shoulders and neck. A plaster collar applied simply to the neck, and not to the trunk, does not give sufficient support except in disease of the upper cervical vertebræ.

The *jury mast* consists of a bent rod of steel running up from the jacket, following the curve of the neck and head to a point above the top of the head. To the end of this rod is attached a cross bar which carries a head sling. The lower end of the jury mast terminates in a metal framework, which is incorporated in the jacket. By raising the head sling the head can be pulled upward. But it is very difficult in practice to keep up continuous traction on the head in this way, and the inconvenience and unsightliness of the apparatus are objectionable.

The chief objection to the treatment of Pott's disease with a perma-

nent plaster jacket is in the uncleanliness. Removable jackets and corsets are not firm. As a base for head supports in the upper dorsal and cervical regions a corset is not readily applied and is more unsightly than a well-fitted appliance; but in the mid-dorsal and upper lumbar region the permanent plaster jacket must be regarded as the most efficient ambulatory fixative appliance.

When a lateral deviation of the spinal column is present with Pott's disease, the jacket is preferable to any brace.

In disease which is very low down, the jacket is often a more efficient and comfortable mode of treatment. For careless and ignorant patients a jacket which is not removable is far preferable to any apparatus which they can misuse. Moreover, the cheapness of the jacket brings it within reach of many people who would otherwise have to go without treatment.

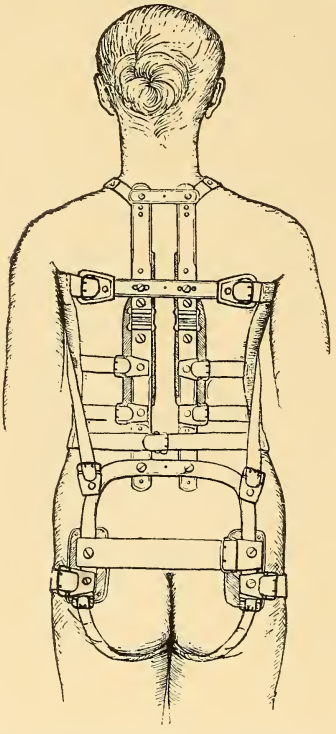


FIG. 71.—Antero-Posterior Support Applied. (Dr. H. L. Taylor.)

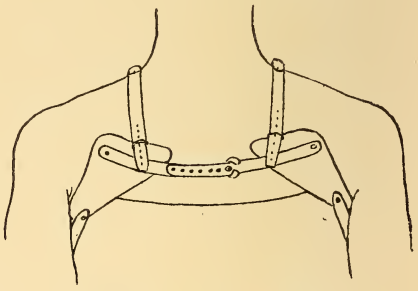


FIG. 72.—Taylor's Chest Piece.

As to the method of application of a jacket, it is to be remembered that the object is to secure fixation of the spine in an improved position. As much force should be used as will secure this without causing undesirable traumatism at the seat of the disease. Suspension alone is the least efficient of all means. Recumbency on the hammock, the kyphotone of Taylor, and the two frames mentioned (all of which induce an improved position by the local use of force) are the most efficient. It is desirable in severe cases to carry the jacket over the shoulders and to have the jackets durable enough to be worn for months. They should be changed with every care not to increase the deformity in the process, even temporarily. The method to be chosen

will vary largely with the familiarity of the surgeon with that especial method. No one of the methods mentioned as efficient is to be advocated to the detriment of the other methods similarly classed.

Treatment by Steel Appliances.

The basis of ambulatory treatment of Pott's disease in the subacute or convalescent stage is fixation, as complete as possible, of the spine

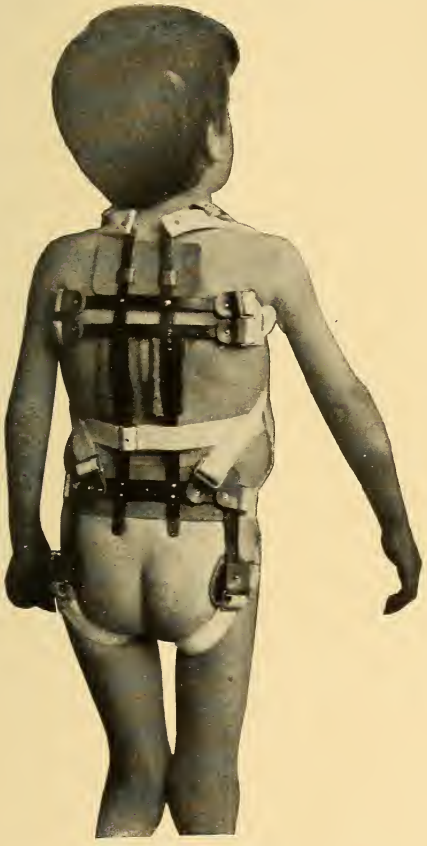


Fig. 73.—Antero-Posterior Brace for Dorsal Pott's Disease Applied.

Fig. 74.—Antero-Posterior Brace for Pott's Disease; showing Apron and Leather Gorget.

in as advantageous a position as obtainable. This may be done by means of a properly made appliance.

As the chief motion of the spine to be guarded against is the forward motion, the principle of the appliance is that of an antero-posterior support. This was first efficiently applied by Dr. C. F. Taylor, of New York, as a method of thorough treatment, as it involves skill and anatomical and pathological knowledge.

The construction and application of a brace should be superintended

directly by the surgeon, and not relegated to an instrument-maker. The details relative to the future result are fully as important as the application of a splint in any fracture, for the result will, in a great measure, depend on the accuracy of adjustment. For the construction of a splint a cardboard tracing of the back should be made at one side of the spinous processes.

The simplest antero-posterior apparatus (Chapter XXI., **4**) consists of two uprights of annealed steel. The uprights are joined together below by an inverted U-shaped piece of steel which runs as far down on the buttock as possible without reaching the chair or bench when

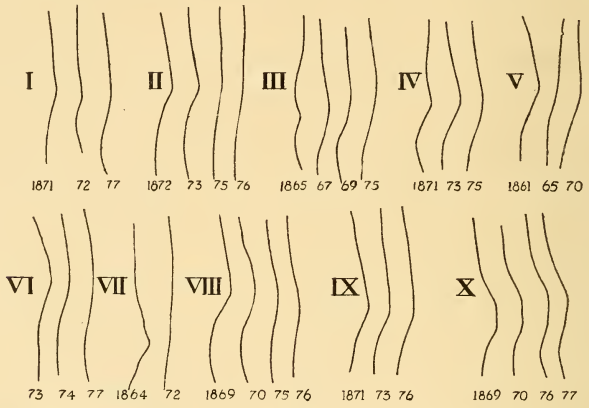


FIG. 75.—Tracings showing Results of Brace Treatment as Carried Out by Dr. C. F. Taylor. *I*, Two and three-quarters years, first and second lumbar disease, five years' treatment; *II*, eight years, eleventh and twelfth dorsal, four years' treatment; *III*, four years, first lumbar, ten years' treatment; *IV*, three and one-half years, six years' treatment; *V*, five years, twelfth dorsal, first and second lumbar, nine years' treatment; *VI*, five and one-half years, sixth and eighth dorsal, four years' treatment; *VII*, about eighteen, dorso-lumbar, eight years' treatment; *VIII*, nine years, seventh to ninth dorsal, seven years' treatment; *IX*, twenty years, five years' treatment; *X*, ten years, eight years' treatment. (Dates are given with tracings; the age given is that at which treatment was begun.)

the patient sits down. Or the brace may end in a waistband. At the top the uprights end in shoulder pieces running over the shoulders.

The brace, after being put together but before being finished, should be tried on the patient, who should be lying on his face. Any alteration necessary in the curves of the steel, in order to have the appliance fit closely to the back along its whole length, can be made with wrenches. The brace can be faced with hard rubber or covered smoothly with leather. An accurate fit is essential; the covering is merely a matter of detail.

Accurately fitting pad plates covered with felt and leather or hard rubber are needed. In some instances, at the points of greatest pressure, the bars of the brace, if well padded, answer every purpose. Buckles are needed at various levels.

If properly designed the appliance will press firmly at the deformity, *i.e.*, the pad plates and pressure should be uniform at this point and closely fitted to the contour of the deformity in all planes. The appliance will also touch necessarily at the top and bottom, but the chief pressure should be at the kyphus. Variations from this type of construction will naturally be of use. Nicety of workmanship in the manufacture of a brace is of relatively secondary importance. The essen-

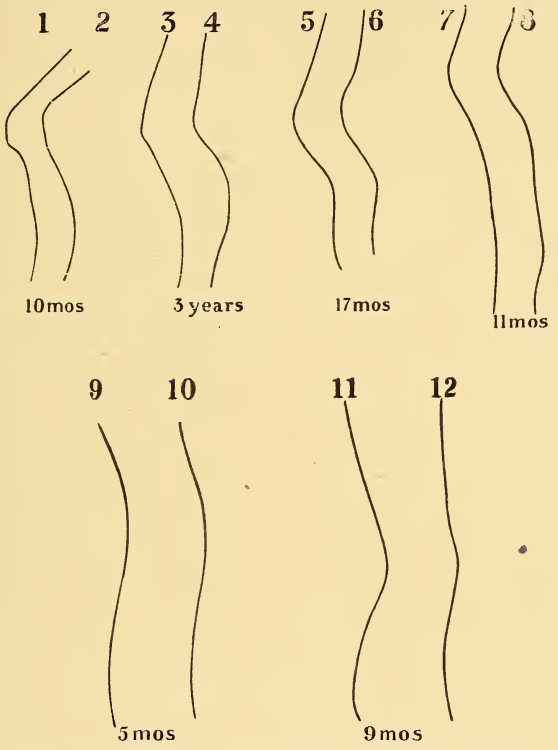


FIG. 75*a*.—Results of Hyperextension Treatment (Goldthwait). 1, At beginning of treatment; 2, ten months later; 3, at beginning of treatment; 4, same, three years later; 5, at beginning of treatment; 6, seventeen months later; 7, at beginning of treatment; 8, seventeen months later; 9, at beginning of treatment; 10, same, five months later; 11, at beginning of treatment; 12, same, after nine months.

tial is that it should be mechanically efficient in meeting the indications of fixation. The construction of the brace does not necessarily involve expensive workmanship, and need not be anything beyond the skill of a village blacksmith. It should be borne in mind that, besides accuracy of fit and proper design, it is of importance that the apparatus be stiff enough not to yield as the weight of the trunk falls upon it, inasmuch as yielding involves intervertebral pressure. This is true not only of the uprights, but also of the band. A stiff appliance, if properly fitted, can be made as comfortable as a yielding one, and is much more efficient.

An error in accuracy of fit may be sufficient to furnish insufficient protection and cause relapse. Moreover, it is necessary that the patient should be seen often enough to keep the brace fitting accurately, for the deformity may increase or diminish at any time. In such a case the brace becomes inefficient.

It is, of course, essential that the trunk be properly secured to the brace. This can be done in part by means of an apron, which covers the front of the trunk, the abdomen, and the chest, reaching from the clavicles nearly to the symphysis pubis. The apron is provided with webbing (non-elastic) straps, which are fastened into buckles attached to the brace. Padded straps, passing from the top of the brace around the arms, under the axillæ, and attached to buckles in the middle of the brace, help to secure it; but the scapulæ, being movable, cannot be relied upon alone to fix the trunk, and the apron must be furnished with straps at the top, which pass over the shoulders to buckles in the top of the brace.

In adults it is often convenient to have the apron split down the front and provided with webbing straps and buckles, so that the patient can adjust it himself by tightening the straps in front.

To secure a proper hold upon the upper segment of the body in dorsal disease some unyielding and rigid chest piece is necessary. Taylor's chest piece acts by means of hard-rubber pads at the upper part of the chest, connected by a steel rod, which keeps the brace closely against the back. The pads of the chest piece may be made of hard rubber and fit in below the clavicles, where they cause no discomfort and restrict the chest movements less than the apron, besides affording more definite support. Other forms of chest piece are in use. A simple one can be made over a plaster cast of the chest by shaping leather which is afterward stiffened by treatment with hot wax. This may be extended upward to support the chin in cases of high dorsal disease. To this hard leather, steel buckles may be attached.

The brace should be worn day and night, and removed daily that the back may be bathed. While the brace is off, the patient should lie on the face or the back. On no account should he sit erect. The back, after being washed, should be rubbed with alcohol and then powdered with face powder, corn starch, or Pears' fuller's earth. The brace should then be applied and buckled tightly into place.

Chafing of the back is sometimes unavoidable in summer. When a severe chafed spot forms, the brace must be removed for the time and the child should lie flat in bed until the ulcer heals. A smooth covering of leather is least irritating to the skin. The brace may be worn over a cloth or undervest, but is least likely to chafe if applied directly over the skin.

Dr. Judson formulates a general rule which may serve as a guide in

the treatment of Pott's disease by rigid apparatus, especially in all forms of the antero-posterior support. The rule reads: "The apparatus may be considered as having reached the limit of its efficiency if it makes the greatest possible pressure on the projection compatible with the comfort and integrity of the skin."

Certain braces have a tendency to "ride-up," and the neck pieces, instead of lying closely to the shoulders, project upward in a most unsightly way. In general, this does not occur in braces which fit accu-

FIG. 76.—Taylor Back Brace with Oval Ring. Head support applied.

FIG. 77.—Antero-Posterior Brace with Bent Wire Head Support.

rately. Sometimes, however, it is most troublesome, and in these cases padded perineal straps can be added, which are attached to the apron in front and to the lower end of the brace behind. They are, however, a source of much annoyance to children, in urination especially, and are to be avoided if possible. The apron will sometimes be found to cut over the anterior superior spines of the ilium and also under the arms, and must be properly padded.

In applying the brace the patient should lie upon his face, and the apron be spread under him. The brace should then be placed in posi-

tion upon the bare back, or upon a thin, smooth cloth without wrinkles, and the apron strapped to it as tightly as is possible. The more tightly the two are strapped together, the more thorough is the fixation. The position of the straps and their number will vary in cases according to the situation of the disease, etc. The brace must, of course, if it is to exert pressure, always be straighter than the spine.

A troublesome complication in the use of the antero-posterior brace is the presence of a lateral curve in the vertebral column; this has been mentioned as an occasional complication of Pott's disease. The brace fits when the child lies down, but when he sits up the column leans to one side again, and it is of course impossible for the brace to fit as before. Fortunately, this symptom passes slowly away as efficient support is afforded to the column, and then the brace fits again. Meantime it is best to apply the brace, bending up one neckpiece and bending the other down to make the top of the brace set squarely, or to apply a plaster jacket, which is ordinarily the most available mode of treatment under these conditions; it is also best to keep the patient in a recumbent position as much as possible until the deformity improves.

The application of the therapeutic principle of fixation in the best possible position varies according as the disease involves the upper, middle, or lower parts of the spinal column.

Head Supports.—In the upper region, as elsewhere, it is desirable to prevent the weight of the head from falling upon the diseased bodies of the vertebræ.

An efficient arrangement is one devised by Dr. Taylor, of New York (Chapter XXI., **5**); an ovoid steel ring passes around the neck, made so that it can open, and be secured when closed, and arranged so that it can serve as a rest for the chin, and so that pressure can also be exerted on the occiput. This collar has at the front a hard-rubber chin piece accurately shaped to the chin, and may have at the back a stiff piece of sole leather projecting up from the back of the ring. This steadies the head and prevents the pressure of the occiput against the back of the headpiece. This collar at the back plays on a pivot, allowing lateral motion of the head. The pivot is attached to the usual back brace, and can be raised or lowered, as it is desired to increase or diminish the upward pressure on the head. This appliance requires care and skill in application, and is useless unless properly fitted.

Other forms of head support have been tried from time to time. Some of them have been useful (Chapter XXI., **6**).

A head support, devised by Goldthwait, affords good fixation. Its construction is evident from the figure, and it is serviceable in cases in which there is excessive sensitiveness of the spine, due to cervical or very high dorsal disease. The quadrilateral back brace devised by

Dane[1] furnishes a useful form of support in Pott's disease (Chapter XXI., **8**).

Collars of various sorts, unattached to any other appliance, have been used, which, pressing on the chin and occiput above, and on the clavicles, sternum, and shoulders below, transfer the weight in part from the intermediate cervical vertebræ and check the forward bending of the cervical region. These collars can be made of plaster of Paris, but are cumbersome and unsightly. The most easily made collar is that invented by the late H. O. Thomas, of Liverpool (Chapter XXI., **7**). Leather stuffed with sawdust is the most available material of which to make them. They may also be made of tin, silicate of potash, wire netting, cardboard doubled and

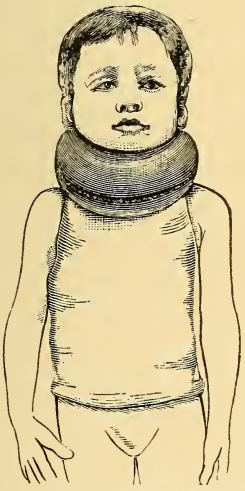


FIG. 78.—Thomas Leather Collar.

FIG. 79.—Leather Jacket with Head Support.

padded, or any of the other materials mentioned in speaking of corsets.

A convenient way of making these collars is by taking a piece of stout webbing, long enough to go loosely around the neck, and winding it with sheet wadding or oakum until it is padded sufficiently. Then it should be covered with a bandage outside, and the ends of the webbing should be buckled together. The patient wears the collar a few days, and then as the padding becomes matted down, new padding

[1] Pediatrics, vol. x., i., 1900.

is added until the collar is the desired size and shape. It is then sent to a harnessmaker to be covered with leather. In this way a much more satisfactory result is obtained than by sending measures to a harnessmaker in the first place.

In all forms of head supports, if worn for a long time, a certain amount of recession of the chin takes place. The nature of this is not clearly understood, but the growth of the lower jaw is in a measure temporarily interfered with, and the front teeth in the lower jaw in severe cases do not articulate with those of the upper. The distortion results from the continued use of any form of head support, and is more liable to occur the more efficient the support. The jaw gradually resumes its shape after removal of the head support.

FIG. 80.—Collar and Chest Piece for Cervical Pott's Disease.

Collars, however, lack in steadiness, and, in order to secure accurate fixation of the head, they should be connected with uprights which extend below and are attached to the trunk. They are adapted only to the treatment of cervical disease of a character not very acute. When torticollis is present as the result of irritation, treatment by recumbency is advisable.

It is hard to say just when the need for a head support begins. In general, if the disease is above the sixth dorsal vertebra, a headpiece is indicated. Sometimes, if the disease is lower down, pain or distortion makes it evident that a head support is needed there also, or it may be necessary to add one if the brace does not make satisfactory pressure at the seat of deformity.

SELECTION OF A METHOD OF TREATMENT.

In the selection of mechanical supports the choice will lie between some of the fixed corsets of plaster of Paris (or the variations of that form of corset fixation) and the antero-posterior supports of steel.

When careful and skilled attention can be applied to the construction, attention, and needed alteration of a brace, it will be found of great efficiency in the treatment of Pott's disease in the convalescent

stage. It should be remembered, as has been shown, that it is impossible to pry the vertebræ apart by leverage, as no apparatus could be worn which would sustain absolutely the weight of the upper part of the trunk from falling forward. The antero-posterior support is to be regarded as an apparatus which modifies rather than relieves intervertebral pressure by the principle of leverage.

The chief objection to the use of mechanical appliances as a method of treatment is that care and special skill are required, not only in the application of braces, but in the inspection and management of the cases.

If the trunk is not thoroughly fixed by the straps, etc., of the appliance, the brace becomes simply a splint of steel laid upon the back, and not a therapeutic agent.

Rectification of the Deformity (Forcible Correction).

Forcible correction of the deformity, with or without anæsthesia, is a method revived in recent times by Chipault, of Paris, although ordina-

Fig. 81.—Pott's Disease before Correction. (Goldthwait.)

Fig. 82.—Same Case Twelve Weeks after Correction. (Goldthwait.)

rily identified with the name of Calot, of Berck-sur-Mer. The latter demonstrated that under an anæsthetic a recent deformity, even of large size, may be partially or wholly corrected. Although it was shown that this is not a proceeding attended with as great risk to life, either near or remote, as would have been supposed, many casualties of various sorts have been reported.

Hemorrhage, rupture of the pleura, rupture of abscesses, and fracture of the spine as well as paralyses are among the results reported, following injudicious application of the method.

In 610 cases[1] reported by various operators, 21 deaths occurred, which is sufficient evidence against the employment of great force.

It is obvious from the inspection of any series of pathological specimens of cured cases of Pott's disease that the diseased tissue is replaced by sound bony tissue to hold the disabled column, if time enough is given and if the process of repair has not been overwhelmed by the process of destruction. Where much force is needed to correct the deformity, the products of cicatrization will be torn or injured in the procedure. This, if extensive, is manifestly to be avoided.

But although the correction of deformity by the use of violence is irrational and may be seriously injurious, the employment of moderate force in correction is frequently beneficial. When ankylosis and cicatricial changes have taken place in the shape of the vertebral bodies, the surgical indications are to be content with the established cure, without incurring the risk of kindling the tuberculous ostitis by violence. In the majority of recent cases, especially in children, this condition of cicatrization has not been reached, as years are usually necessary before a cure is accomplished, and in these the kyphosis can generally be made straighter by the use of comparatively moderate force without the need of an anæsthetic.

The mechanical means for rectification are those already mentioned as of use in the application of plaster jackets. Rectification judiciously applied is beneficial in all active cases of Pott's disease. Pressure symptoms will be relieved and in some instances paralysis checked.

In older cicatrized cases great judgment is necessary in the employment of correcting force.

It must also be understood that after correction a relapse of the curve will take place unless the corrected position is maintained by adequate fixed appliances until the spine is well cicatrized in the corrected position.

Operations on the Diseased Vertebræ.

Operative measures are necessary under exceptional circumstances for the direct examination of the diseased vertebral bodies and the removal or drainage of the diseased bone. It must be remembered that in any event the vertebral bodies are more or less inaccessible, and that such operations are not likely to prove of benefit as routine measures.

In the cervical region the anterior surfaces of the bodies of the ver-

[1] E. H. Bradford and Vose, giving bibliography: Trans. Am. Surgical Assn., 1899 —Bradford and Cotton: Boston Med. and Surgical Journal, September 20th, 1900.

tebræ may be reached either through the mouth, by a lateral incision, or by incision in the back of the neck. Through the mouth the operating space is small, the proceeding difficult on account of the anæsthetic, and the dangers of infection are evident. This method makes accessible only the second, third, and fourth vertebral bodies. The lateral method is preferable. An incision is made along the posterior border of the sternomastoid muscle; the sternomastoid and omohyoid are raised and the space made by the splenius and omohyoid is reached. The dissection is carried through the longus colli, and the vertebral arteries are avoided.

In the dorsal region exploration may be advisable in case an abscess in the posterior mediastinum is suspected. In such cases the operation of costo-transversectomy should be done. An incision at the side of the spinous processes uncovers the tops of the transverse processes and the bases of the ribs. The ribs are divided at the tuberosities and, with the transverse processes, removed. The spine is then reached by the finger.

In the lumbar region an incision is made from the twelfth rib to the ilium, two and one-half inches outside of the median line; the incision reaches to the border of the quadratus lumborum and the tips of the transverse processes should be felt. The dissection is carried down to the psoas muscle; some of the fibres of this muscle are detached with care from one transverse process. The finger introduced reaches without difficulty the anterior surface of the vertebral bodies. The finger can strip up the psoas muscle through this incision and explore the vertebral bodies. The vertebral canal should not be opened.

Treatment of Abscess.

Abscesses may be treated by expectancy or by operation.

(1) **Expectancy.**—Under proper treatment early abscesses may subside and be absorbed without detriment to the patient.

Recumbency under the best mechanical conditions, preferably in the open air day and night, will favor the tendency to absorption. Aspiration will diminish the size of an abscess, but if it does not tend to absorb under the conditions mentioned, and especially if it shows a tendency to increase, it is better not to temporize, but to incise. The injection of abscess cavities with germicidal solutions should be regarded as imperfect and not meeting the surgical indication of drainage.

(2) **Operation.**—When abscesses increase rapidly, or for any reason seem an injury to the patient, incision is to be considered.

Incision of an abscess should be made under thorough aseptic precautions, and as complete drainage as possible secured; but it must be remembered that owing to the depth of the origin of abscesses in Pott's

disease perfect drainage is not always as easily furnished as in more superficial abscesses. It is therefore desirable, especially in adults, to delay incision longer than would otherwise be surgically indicated. It is also to be remembered that as the focus of the disease has not been reached, a discharging sinus will persist and will ultimately become infected with pyogenic organisms, thereby adding a pyogenic to a tuberculous infection.[1]

In retropharyngeal and cervical abscesses, however, drainage can ordinarily be readily secured. In dorsal abscesses an incision in the back is frequently sufficient; but in some instances it will be necessary to perform costo-transversectomy to secure perfect drainage. In lumbar and iliac abscesses it may be necessary, owing to the depth of their origin, to incise both in front and behind, which can be done with care without opening the peritoneal cavity.

The above-mentioned facts must be borne in mind in advocating operation when it is not indicated by pressure effects and the distention of the abscess.

Psoas abscess may be opened in the loin or in the iliac fossa, or in both places. Drainage may be made with a strip of gauze or a rubber tube and the dressing kept sterile as long as possible. After incision curettage is not desirable, as it is impossible to remove all of the diseased material and unnecessary traumatism is to be avoided. Flushing with sterile hot water is all that is required. It must be remembered that communication in front of the vertebral column may exist between the psoas sheath of one side and that of the other.

A *retropharyngeal abscess* is best opened by passing into the mouth a bistoury wound to within half an inch of its point with cotton, and cutting freely, using the finger as a guide. The child should be held face downward in order that the pus may not enter the trachea, and plenty of swabs should be at hand to keep the mouth clear, for the gush of pus is sometimes considerable. Such abscesses may also be opened by lateral incisions from the outside.

Abscess in the mediastinum is opened as described above in speaking of costo-transversectomy.

Other abscesses are opened on general surgical principles.

Treatment of Psoas Contraction.—When flexion of one or both thighs has come on it is not likely to diminish spontaneously, and if the condition is allowed to go untreated, such contractions may become permanent.

A permanent contraction of one or both psoas muscles with the thigh flexed is a serious deformity. If it exists on both sides, the patient can walk only with the trunk held nearly horizontal. If it is unilateral, it leads to a very serious disability, requiring in most cases the

[1] Schuckhardt and Krause: "Die Tub. der Knochen und Gelenke."

use of a crutch, for the diseased spine cannot be flexed to allow the foot to reach the ground in walking as it does when flexion of the thigh exists as a result of hip disease. For these reasons it is desirable to attack psoas contraction with very vigorous measures, which afford a prospect of averting any permanent contraction.

In the early stages the child should be put to bed on a frame. A light extension should be applied to the leg with pulley extension, and the pulley should be gradually lowered until the leg is straight and the flexion overcome. In cases in which the flexion has existed only a few weeks or months, this is generally easily accomplished in two or three weeks. If not, or if a more rapid method is desired in the first instance, the child should be anæsthetized and the leg straightened by force and retained by plaster of Paris. If this cannot be done with the use of moderate force, it is better to divide and cut the fascia and the contracted bands—an operation which cannot often be done thoroughly subcutaneously, for there are many deep bands.

The deformity is almost sure to return if the patients are allowed to go about, and they should either be kept on a frame or an arm should be extended down from the brace or the jacket to keep the thigh fully extended. Finally, subtrochanteric osteotomy of the femur may be necessary in severe cases, but it should not be done until after recovery from the Pott's disease.

Treatment of Paralysis.

When paralysis is threatened, the patient should be put to bed on a frame so padded as to press upon the deformity and hold the vertebræ somewhat separated. In dorsal cases traction may be added. An attack may thus be averted.

When paralysis is present, a plaster jacket should be applied in strong hyperextension of the spine at the seat of the deformity (by one of the methods mentioned), and the patient should be kept recumbent until the paralysis begins to disappear.

The tendency of the paralysis is strongly toward recovery under favorable conditions of treatment. Taylor and Lovett found, in forty-seven cases in private practice, eighty-three per cent of recoveries. The average duration of the cases was one year, but when the paralysis came under treatment the average was only seven months. Relapses occur at times, and although the loss of sensation and paralysis of the sphincters are symptoms pointing to a serious involvement of the cord, recovery may follow.

These considerations bear strongly on the question of operative treatment for paralytic cases.

Drugs are of little or no value, and it is not possible to attach much importance to the use of the cautery or of counterirritants.

Laminectomy.—A spicule of bone or an intraspinal abscess may be the source of pressure at any stage of the disease, and in such cases, of course, operation is demanded. In cases of long standing in which the paralysis has become very extensive and has involved sensation, and possibly the sphincters of the bladder and rectum, the question arises as to whether the operation is likely to be of benefit or whether the damage to the cord is not already irreparable.

The operation consists in cutting down upon the spinous processes in the region of the deformity, the incision being slightly to one side of the centre, so that the resulting cicatrix will not be unduly pressed upon during recumbency. All the soft tissues are then stripped with a periosteal knife, until the laminæ are exposed. The spinous processes are then removed with bone forceps over the affected area. Laminectomy forceps are then used to cut away all of the laminæ covering the cord at the seat of pressure. The dura may or may not be opened. A probe is then passed up and down the spinal canal, to be sure that all pressure is removed, and the wound is dressed. The patient should be laid on the face after operation if it is more comfortable.

It may be said that resection of the laminæ of the vertebral column is an operation which is not gaining in favor. The death rate is high (36.44 per cent), and with the more efficient treatment of paralysis by mechanical means laminectomy must be reserved for the gravest cases which show no sign of improvement after a faithful and long-continued trial of the ordinary measures. But at the same time brilliant successes at times follow the operation, so that it holds out the hope of relieving cases of paraplegia which would otherwise have been hopeless. The operation, however, has no place in the treatment of Pott's disease until the conservative measures have been faithfully tried over a sufficient period of time—measures which in most cases will prove efficient and successful in the relief of the paralysis. Immediate improvement is not necessarily to be expected.

SUMMARY OF TREATMENT.

The proper treatment of Pott's disease is not the application of any method, the use of any corset or brace, but the employment of such means as are most efficient for carrying out the object aimed at. A brace is useless in the case of persons unable to adjust it; a plaster jacket applied about the trunk is useless in disease of the cervical or high dorsal region. Recumbency, carried to a point of depressing the patient's mental and physical condition, is as much of a mistake as to drag a patient about who is anxious to lie down.

In the treatment of these cases, the surgeon should be familiar with the advantages to be gained by all methods, and should employ each

as the case may demand, and for such a length of time as the circumstances of the case may require, or combine the different methods as may be advisable.

In a general way he may formulate to himself that: in acute, painful cases absolute recumbency with proper fixation is the best method until the active stage of the disease is passed; in middle and lower dorsal Pott's disease an immovable plaster jacket, without head attachment, in the case of negligent persons, is most available.

Whether recumbency for a time is required, or whether ambulatory treatment with fixation appliances is sufficient, are questions of judgment in individual cases.

A choice between plaster jackets and steel appliances is a choice between a fixed and a movable support. The former is better in the more acute forms of the disease. The latter requires constant and faithful attention to guard against imperfect or loose application and inadequate support.

Apparatus carefully adjusted and applied is evidently preferable to removable plaster and other corsets, being less clumsy, but apparatus properly made is both more expensive and demands more skill and time on the part of the surgeon.

In cases of Pott's disease the treatment involves much responsibility and cannot be left to a mechanician unfamiliar with the pathological conditions, as is sometimes done. The surgeon should familiarize himself with every detail and be responsible for this as well as for the general treatment.

CHAPTER III.

TUBERCULOUS DISEASE OF THE HIP.

Definition.—Pathology.—Clinical history.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment (mechanical—operative).

The affection which is commonly known as hip disease is the most frequent affection of the hip-joint, and by common usage the general name of "hip disease" or "hip-joint disease" has become limited to that especial affection of the joint which comes now for consideration. It is known also by the names of morbus coxarius or morbus coxæ, coxalgia, coxitis, chronic articular ostitis of the hip, and coxo-tuberculose (Lannelongue). The pathological condition commonly found is a chronic tuberculous ostitis of the epiphysis of the head of the femur or of the acetabulum.

PATHOLOGY.

The pathology of hip disease in general does not differ from that of tuberculous disease of bone which has already been referred to.

The head of the femur is the primary seat of disease,[1] in a majority of the cases the epiphysis or juxto-epiphyseal region being the part attacked. In about twenty-five per cent of the cases the primary focus is in the acetabulum.

When once the acetabulum has become diseased either primarily or secondarily, enlargement of it is apt to take place. The irritated pelvic femoral muscles which are in a state of tonic contraction crowd the head of the femur against the upper and back border of the acetabulum; under this continual pressure absorption of that portion of the rim of the acetabular cavity takes place with an actual enlargement of the cavity from below upward. This so-called migration of the acetabulum is one cause of shortening of the limb, and measurement will show that the trochanter lies above Nélaton's line.

The changes in the head of the femur are chiefly the result of ostitis and pressure. There may be alteration in the shape of the head of the bone, if it is worn away by the pressure induced by constant muscular spasm with destruction of the articular surface.

[1] König: Deutsch. Zeit. f. Chir., xi., 1879.—König: "Die spec. Tuberc. der Knochen und Gelenke," Pt. II., Berlin, 1903.—G. A. Wright: "Hip. Dis. in Childhood," p. 17.—Habern: Cent. f. Chir., April 2d, 1881.—E. H. Nichols: Orth. Trans., vol. xi., p. 353.

"Dislocation" of the hip in hip disease is a term often used which is perhaps misleading. Partial destruction of the softened head of the femur in the manner just described may lead to a shortening of the limb and to an elevation of the trochanter above its proper level. The wearing away of the acetabulum produces the same result; but true dislocation is rare, because, even if the head of the bone is almost en-

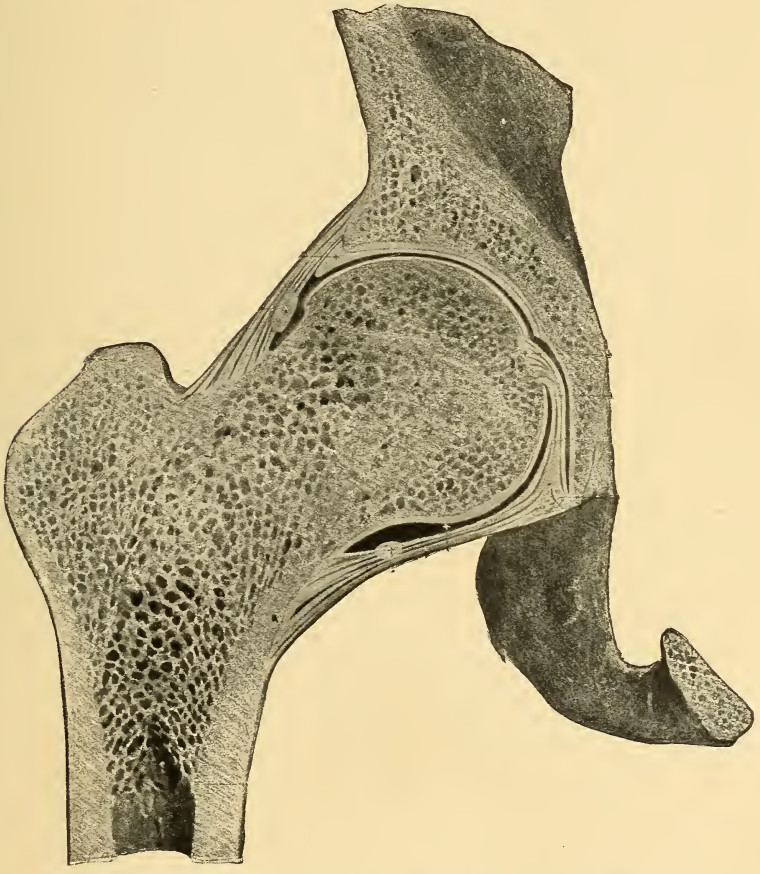


FIG. 83.—Frontal Section through a Normal Right Hip Joint in an Adult.

tirely destroyed, there is so much inflammatory tissue deposited about the joint that the head of the bone is retained partly in place.

Fracture of the atrophied and degenerated shaft of the femur may occur in occasional cases. Separation of the head of the femur at the epiphyseal line is less uncommon.

A typical specimen from a fairly advanced case of hip disease shows a reddened and thickened synovial membrane, often with granulations; the cartilage is gone from the head of the femur or hangs in tags or shreds, and the general appearance of the end is often spoken of as

"worm-eaten"; sometimes the whole cartilage may be lifted from the bone by a layer of granulations. The epiphyseal portion of the head of the femur has disappeared in part or altogether, and a ragged, carious end of bone will articulate with an acetabulum covered with fungous granulation in part or wholly replacing cartilage.

The whole epiphysis may form one sequestrum, but this is not common in tuberculous ostitis, though not as rare in infectious ostitis.

FIG. 84.—Erosion of the Upper Part of the Acetabulum. (Warren Museum.)

Perforation of the floor of the acetabulum may take place. Inside of the pelvis a dense wall of fibrous tissue and thickened periosteum shuts off the head of the femur or the contents of the joint from the pelvic cavity. In cases in which the disease has gone on as far as this, disease of the pelvic bones may coexist. In the other direction, when once the disease of the femur has passed the epiphyseal line, there is no limit to be set to its course or its extent of destruction.

Abscesses appear externally if the disease of the joint extends to the periarticular tissues or when a separate focus of disease forms out-

side of the joint and spreads to the surrounding soft parts. Suppuration inside of the pelvis is not a very uncommon condition in the ace-

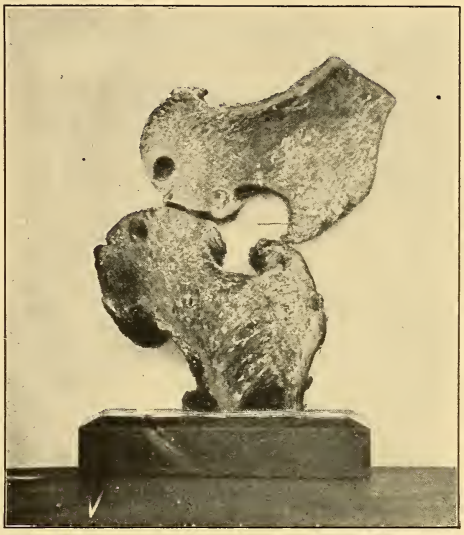


FIG. 85.—Focus in Head of Femur.

tabular form of the disease; in the femoral form it accompanies only advanced disease.

A natural cure results in one of two ways: by the absorption or cal-

FIG. 86.—Separation of the Head of the Femur at the Epiphyseal Line.

cification of the tuberculous tissue at an early or a late stage of the disease; or by the purulent degeneration of such tissue and its evacuation and discharge by an external opening. The suppuration which comes

later seems to be nature's effort to eliminate the diseased material, and it is the common method by which spontaneous cure results when it does occur. This late stage of the disease is characterized by malpositions and shortening of the limb and much impairment of the general condition in most cases. It is this state of affairs that makes the spontaneous cure of hip disease undesirable and imperfect. When spontaneous cure does occur it is usually with an ankylosed joint.

In these cases, however, one sometimes finds at autopsy an included cheesy focus which still presents some signs of activity. It is to these foci that one looks for an explanation of the late relapses of the disease and the very great harm

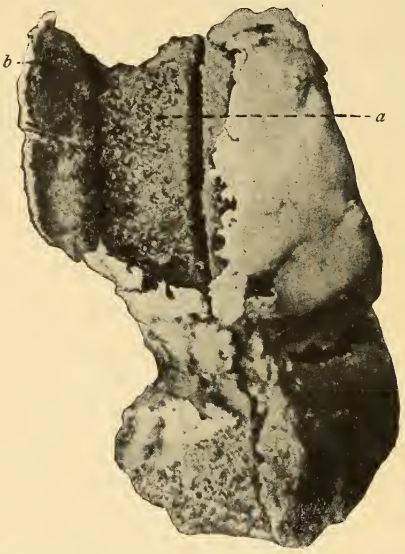


FIG. 87.—Hip. Excised head of femur. Articular cartilage turned up at one side shows tuberculous bone beneath. Primary focus was in acetabulum. *a*, Head of femur, surface tubercles; *b*, elevated cartilage. (Nichols.)

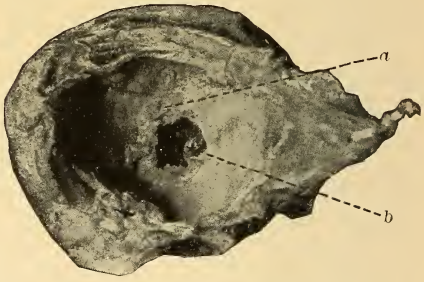


FIG. 88.—Acetabulum Seen from Outside. *a*, Tuberculous granulations; *b*, tuberculous cavity. (Nichols.)

which is sometimes done by forcible manipulation of these joints and consequent lighting up of the original tuberculous disease.[1]

CLINICAL HISTORY.

Early Symptoms.—The beginning of the affection is most often gradual and insidious, but at times it begins so abruptly, according to the parents' account, as to suggest a traumatic origin. The child will be noticed to limp at times with intervals of comparative freedom from lameness. This lameness increases, and it will be found that the patient is inclined to strike the ball of the foot rather than the heel in walking; although the heel can be put down to the floor, yet instinctively the knee is slightly bent and the heel raised when the weight of the trunk falls on the hip. There is a certain amount of stiffness of gait apparent in the morning when the patient first gets out of bed, and after sitting

[1] Trans. American Orthopedic Association, vol. i.

for a while; this passes away after the patient has walked or played about. At night, as a rule, the limp is less than in the morning. The limp can perhaps best be described as a very slight stiffness and a disinclination to bear prolonged weight upon the affected limb.

If the child be inspected it will be seen that in standing the knee of the affected side is often flexed slightly, the pelvis being tipped and the thigh slightly abducted. The tilting of the pelvis and abduction of the thigh may be so slight that it is scarcely noticeable, except by

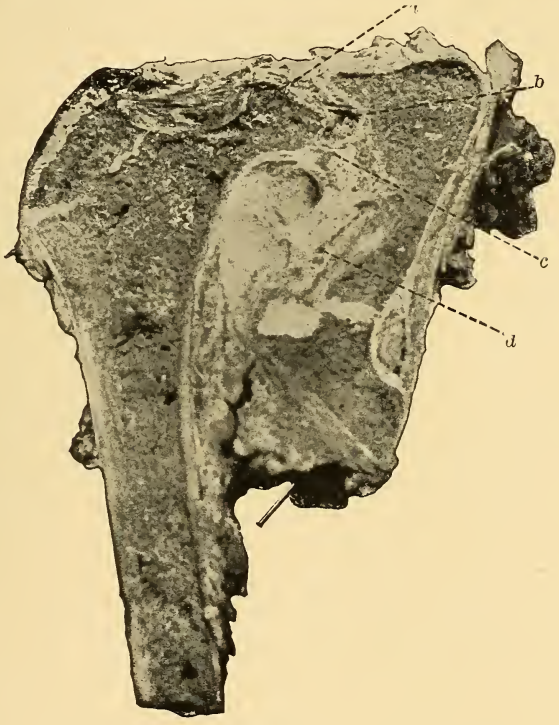


FIG. 89.—Head of Femur Eroded, Partly Destroyed, Partly Dislocated. Fibrous ankylosis. *a*, Head of femur; *b*, eroded head of femur; *c*, ankylosis; *d*, acetabulum. (Nichols.)

the deviation from the median line of the fold between the two buttocks. In girls the vulva on the affected side may be lower than on the other side.

Pain at this stage is very often absent, and if present is noted as night cries, to which allusion will be made.

Course of Disease.—It has been customary to divide hip disease into stages and to ascribe to these stages certain definite symptoms. Neither from a clinical nor a pathological standpoint is it desirable to attempt any such division.

In the early part of the disease pain at night, stiffness, and limping

are the chief symptoms. Then follow malpositions of the limb, more severe disability, and perhaps greater pain and sensitiveness.

Succeeding the deformities which have just been described, one may find abscess formation and the development of sinuses; and this stage of the affection will hardly have been reached without considerable constitutional deterioration, which may become severe.

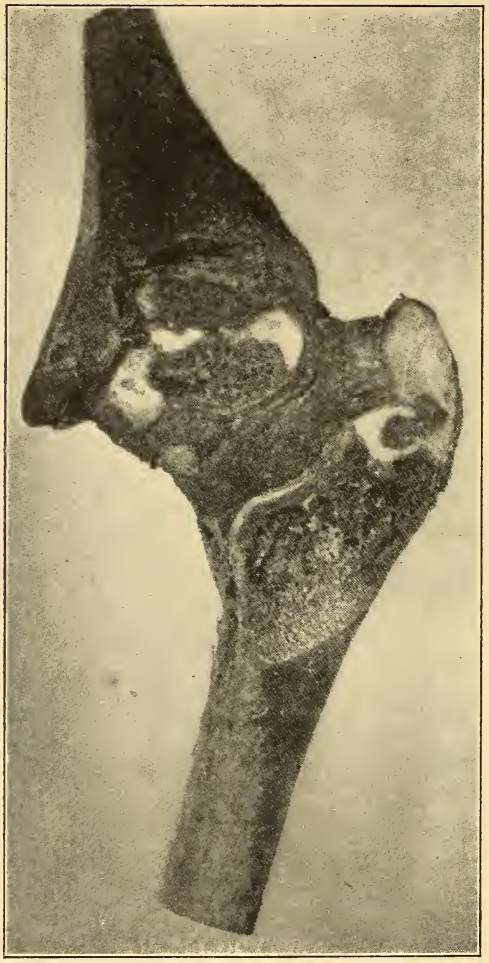


FIG. 90.—Hip-joint from Boy Nine Years Old. Hip disease had existed six years previously and had been treated by traction. Death from meningitis. Specimen shows no widening of acetabulum, and but little alteration in the head of the femur.

Lameness.—From being at first scarcely perceptible, the lameness increases and the limp becomes very noticeable. In very acute cases pain may become so severe that the child will refuse to use the leg, or malposition of the leg may come on rapidly and the limp may on that account become excessive; but in general the child walks without pain, though perhaps limping badly. Until the late stages of the disease lameness is not due to bone shortening.

Pain.—As the affection progresses, pain in the knee and sensitiveness to jarring the limb may become prominent symptoms. An unconscious protection of the joint may be noticed in the movement of the patient; the foot of the well limb may be placed under the lower part of the other leg when it is to be suddenly lifted by the patient, as from the floor to the bed, or from the bed to the floor, or in moving from one side of the bed to the other.

In manipulating the leg at this stage pain may follow the slightest

jar to the joint, or, on the other hand, the joint may be perfectly stiff from muscular spasm and yet manipulation may be wholly painless. In other cases motion in a certain arc is possible without causing pain, but when the limits of this arc are reached, further motion becomes painful or is prevented by muscular fixation. The sensitiveness of the joint may become so great, when an acute stage supervenes, that the slightest movement of the patient or jar of the bed or room causes extreme suffering. This stage may come suddenly and gradually pass away, the pain diminishing by degrees under the enforced treatment of rest, or it may be persistent. A characteristic position is frequently taken by the patient, who places the well foot on the dorsum of the foot of the

FIG. 91. FIG. 92.

FIG. 91.—Specimen from Excision of Hip when Traction has not been Employed. Severity and duration of disease similar to that of case in Fig. 92.

FIG. 92.—Specimen from Excision of Hip Treated by Efficient Traction for Three Years. Operation done because of failure in general condition.

affected limb, exerting pressure away from the acetabulum. *Pain may be absent at any or all stages of the disease, and is not a diagnostic sign for or against the presence of hip disease.* Sensitiveness may be absent, upon which condition, however, at any time a sensitive condition of the joint may supervene. The pain is often remittent, and here, as in all the symptoms of this affection, marked remissions may occur. The location of the pain is variable, but is generally referred to the inside and front of the thigh near the knee or directly at the knee-joint. The intimate relations and anastomoses of the sciatic, obturator, and anterior crural nerves seem to furnish the best explanation of this.

In a minority of cases the pain is referred to the joint itself. In the more acute cases sensitiveness to pressure on the trochanter and to deep pressure over the anterior surface of the joint (just below the anterior superior spine of the ilium) is present.

Night Cries.—At an early stage of the affection the symptoms of "night cries" often appear. They occur in the early part of the night usually, and may become an annoying symptom. After the patient is asleep, and to all appearances entirely unconscious, sleep will be interrupted by a cry as if of severe pain, followed by moaning or crying for a few seconds; the child being unconscious or only half-conscious of the cause of the pain. These do not often occur when the patient is entirely awake, and are caused by the spasmodic twitching of the muscles abnormally excitable from irritation, reflex to the inflammation of the joint. These cries may be repeated fifteen or twenty times during the night. They may be entirely wanting in the mildest cases.

Muscular fixation (muscular spasm) is always present in some degree, restricting the joint's normal arc of motion. It is due to a reflex irritability of the muscles controlling the joint, which causes them to

FIG. 93.—Instinctive Effort at Traction in Acute Disease of the Left Leg. (Fisk Prize Fund Essay.)

maintain a condition of tonic spasm of greater or less degree. It disappears under full anæsthesia. Increased stiffness appearing in the course of treatment is a sign of inefficient treatment or of increase of the disease. This muscular rigidity is the most important sign of the disease, for not only is it the chief reliance in the matter of diagnosis, but it is the cause of the malpositions of the limb, of the wearing away of the acetabulum and of the head of the bone, and it lies at the root of much of the pain. It furnishes the most accurate index of the progress of the case, and improves or becomes worse as the case becomes better or worse. The importance of the recognition and accurate study of this symptom cannot be overestimated.

If a child with severe hip disease be laid on his face and lifted by the legs with a view to determining the flexibility of the lumbar spine, one can often notice the lumbar muscles stand out like cords, and hold the lumbar spine quite rigid. This often gives rise to the suspicion of the coexistence of Pott's disease. This symptom is present only in the severer forms of hip disease.

Atrophy.—A marked atrophy of the muscles of the thigh, hip, and leg is characteristic. It is supposed to be reflex to the disease of the joint.[1]

Atrophy of the muscles controlling an inflamed joint begins early and may be very marked, even in simple acute synovitis. That this is something more than the mere atrophy of disuse is shown by the fact that it begins so sharply and so early, that it is greater in the diseased limb than in the well one even when the patient has been in bed from the first, and that the muscles, although atrophied, are not soft and flabby, but tense.

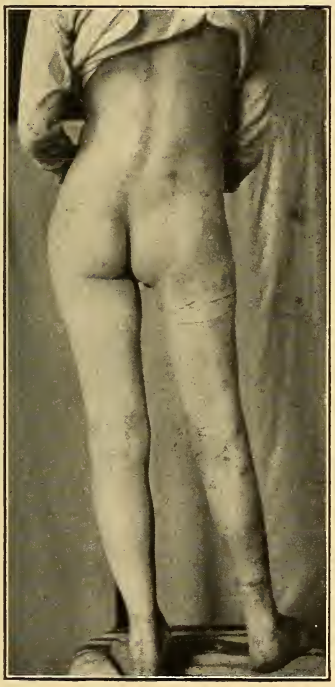


FIG. 94.—Obliteration of Gluteal Fold in Hip Disease of Right Side.

FIG. 95.—Position Assumed in Standing, with Slight Abduction of the Right Leg.

Diminished resistance to the passage of the *x*-rays in the epiphyses of the hip, indicative of greater vascularity, may be seen in the earlier stages of hip disease.[2]

Increased patellar reflex is generally present in the affected leg dur-

[1] Emile Valtat: "L'Atrophie Musc. dans les Mal. Articulaires," Paris.

[2] Lovett and Brown: "The Diagnostic Value of the *x*-Ray in Hip Disease," Phila. Med Journ., Jan. 28th, 1905.

ing the early part of the disease and the thigh muscles show a diminished contractility to the faradic current.

Atrophy generally can be easily appreciated at an early stage of the disease by grasping the muscles in the hand or by measurement with a tape. The difference in the circumference of the two thighs will be perhaps one-quarter of an inch to an inch, and the difference in the size of the calves is generally about half of the thigh difference. In children who can use the leg fairly well there is rarely any calf atrophy at the first examination. The obliteration of the fold of the buttock on the affected side is a result partly of muscular atrophy and partly of the periarticular swelling which accompanies the disease. It is a common but not a constant symptom at the early stages of the disease. It is also partly due to the flexed attitude of the limb, which naturally diminishes the prominence of the buttock on that side.

Malpositions of the Limb.—The fixation of the diseased limb in a distorted position is one of the commonest incidents of the affection.

FIG. 96.—Severe Abduction and Eversion in a very Acute Case.

This is due to the tonic muscular contraction so often alluded to. These malpositions may hold the limb in flexion, adduction, abduction, or eversion, or in any combination of these; the cause which determines the kind of malposition in an individual case cannot be formulated. Flexion of the thigh is chiefly due to the muscular contraction, which is constant in chronic disease of the joint, and partly to an unconscious effort on the part of the patient to assume a position most comfortable for the joint and most protected from jar.[1] These deformities[2] generally disappear under treatment by rest or traction; but again, they reappear in cases under treatment if treatment has not succeeded in checking the progress of the disease. They often accompany a sensitive condition of the joint, which may be the precursor of abscess.

If the malposition is allowed to become permanent the final result

[1] Lannelongue: "Coxotuberculose," Paris, 1885.—Hilton: "Rest and Pain," London.

[2] H. M. Sherman: Orth. Trans., vol. xii.

can never be so good as when cicatrization takes place in a more normal position. The limp in ankylosed limbs depends more upon the amount of flexion and adduction than on anything except perhaps the bone shortening. It is, therefore, of much importance to diminish in all cases the amount of malposition present.

When adduction is present in both legs, as in double hip disease, and ankylosis of both hips has occurred, cross-legged progression may be necessary on account of the inability to separate the legs.

The position in standing and lying is modified by the occurrence of these malpositions; abduction or adduction causes tilting of the pelvis, and flexion causes a marked lordosis of the lumbar spine in standing

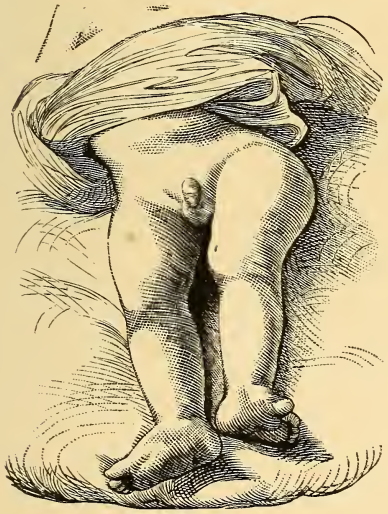


FIG. 97.—Adduction of the Left Leg in Acute Hip Disease.

FIG. 98.—Case Showing Marked Flexion with Adduction of the Left Hip Joint.

with the legs parallel; by standing with the diseased leg somewhat flexed the lordosis can be overcome. The same arching of the lumbar spine occurs when the patient lies on a table and the flexed leg is brought down.

Periarticular Symptoms.—An important sign is found in the thickening over the anterior surface of the joint when palpated in the groin as contrasted with the other side. An indefinite oval thickened area is felt deep down. At other times the thickening is most marked at

the posterior aspect of the joint, behind the trochanter. This sign is an early one and of great value in the early recognition of the disease. A density in the superficial tissues over a diseased hip which the other side does not possess is often found at a comparatively early stage of the affection. Behind or in front of the trochanter the deep tissues are resistant and the fossa existing there is filled out, and the great trochanter feels enlarged and thicker than its fellow when grasped by the fingers deeply pressed in.

FIG. 99.—Left Hip Disease with Abscess on Outer Side of Thigh.

The inguinal glands of the affected side are often enlarged and they may be so much distended that they obstruct the venous return and the skin may be marbled with superficial veins. They are at times the seat of superficial abscesses. A gland lying on the iliac vessels is frequently found enlarged in hip disease and is palpated just above the ramus of the pubis. In very severe cases the upper part of the thigh and the tissues in the vicinity of the hip may become swollen generally from an œdema of the periarticular tissues. This may disappear or become localized in the formation of an abscess.

Abscess.—In a proportion of cases suppuration takes place. The site and course of the abscesses vary according to the seat and size of the original focus of the ostitis, whether in the femur or acetabulum. Abscesses may be entirely periarticular, if the initial lesion of the epiphysis extend in a course outside of the joint; or, as is commonly the case, they may come from suppuration within the joint; or, having been periarticular, they may later involve the joint.

The invasion of the abscess is frequently without constitutional disturbance; exacerbation of pain and joint symptoms is, however, a frequent accompaniment of this formation. Abscesses may be absorbed or may evacuate themselves spontaneously either completely or partially, the residual fluid following along the course of the sheaths of the muscles and the fasciæ, reappearing later as secondary abscesses, the

same abscess causing five or six fistulous openings. These openings discharge pus and serum for months and years in most cases. These sinuses after a short time become infected with pyogenic organisms. With the bursting of an abscess and the discharge of any considerable quantity of pus the patient's condition may show rapid improvement, or, if imperfect drainage takes place, reaccumulation of the pus may occur and the patient's condition may become worse.

When the pus has left the joint it generally burrows between the thigh muscles to reach the skin, where it appears as a swelling of varying size. Fluctuation is usually marked. As the abscess invades the skin the latter becomes thin and red, and ulcerates in one or two places, evacuating the abscess. The contents of the abscess may, however, in a few instances be absorbed even at a stage when fluctuation is marked, and the swelling may disappear, perhaps leaving a depression beneath the skin.

The pus most commonly reaches the skin at the anterior border of the tensor vaginæ femoris muscles; it may, however, gravitate backward and open back of the great trochanter or at the lower border of the glutæus maximus; it may come around to the inner side of the

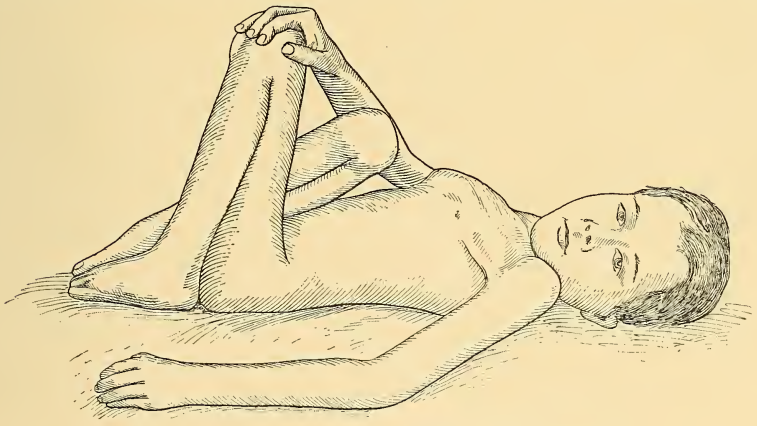


FIG. 100.—Deformity in Untreated Double Hip Disease.

thigh and perhaps open in front of the adductor tendons or even discharge into the rectum; finally, it may ascend the sheath of the psoas muscles and point above Poupart's ligament, or it may descend in the thigh muscles and point in the popliteal space. The seat of the primary disease cannot be inferred from the situation of the abscess.

Abscess is very often the result of inefficient treatment and improper care.[1]

Shortening.—The effect of persistent muscular spasm of muscles about the hip-joint, characteristic of hip disease, is to crowd the femur

[1] Lovett and Goldthwait: Ortho. Trans., vol. ii., p. 82.

against the acetabulum and to produce the enlargement of the acetabulum and the absorption of the head of the femur, with resulting shortening of the limb.

In addition to the shortening produced by absolute destruction of bone in the femur or the acetabulum, there is a decided trophic disturbance of the limb which results in retarding the bony growth and causes at the same time a certain amount of bone atrophy; retarded growth of the affected limb becomes evident in the early months of the disease, and is a permanent condition which is not outgrown as years go on, for the affected limb always lags behind the other in its growth.

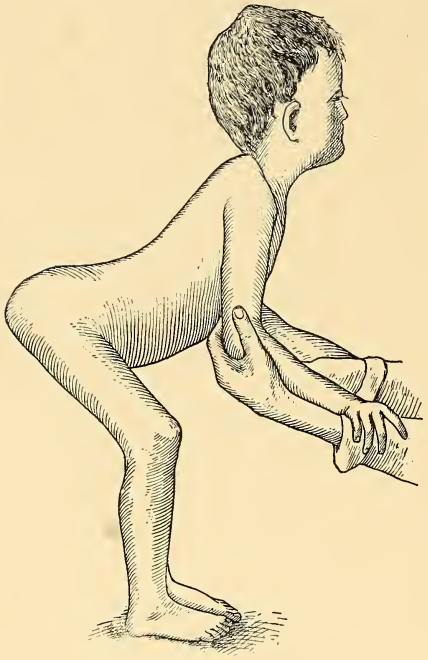


FIG 101.—Position Necessitated by the Permanent Flexion Deformity Resulting from Double Hip Disease.

The shortening may be evenly distributed between the bones of the leg and those of the thigh, or it may be most marked in the bones of the leg. When there is much shortening of the leg, the foot of the affected side is also smaller than the other. The difference in the length of the legs almost always increases slightly after the disease is cured.[1]

General Condition.—Children with hip disease are often robust at the beginning of the affection and sometimes the general condition continues good, but these cases are exceptional. More often the child is pale and the appetite fails at times; there is often loss of flesh; in some mild cases and in most of the severe ones decided constitutional disturbance results.

Remissions.—Any account of the symptoms of hip disease would be incomplete without speaking of the remissions in the course of the affection. In the early stage this is especially noticeable, and a patient may to outside appearances entirely recover from the symptoms of pain, lameness, and discomfort for some days or weeks. Then the symptoms return with increased vigor, perhaps to disappear again in a short time. The muscular stiffness does not wholly disappear at these times, although it may improve along with the other manifestations of the dis-

[1] Shaffer and Lovett: N. Y. Med. Jour., May 21st, 1887.

ease. The later course of the disease is marked by much greater uniformity, but even then temporary improvement may be quite marked.

Temperature.—Children with hip disease under treatment by ambulatory measures have as a rule a higher afternoon temperature than normal. In 627 observations made on cases of hip disease and Pott's disease at the Out-Patient Department of the Children's Hospital a rise of temperature of one or two degrees was common. Ninety per cent of all cases, acute or chronic, mild or severe, had an evening temperature of at least 99°, and a rise to 103° or 104° in severe cases was not necessarily an indication of abscess.

Double Hip Disease.—The disease seldom begins in both hip-joints at the same time, and the second joint may become inflamed while the patient is under treatment in bed for the first joint.

The course of double hip disease would appear to vary somewhat from that of single hip disease. It is, as a rule, of a severe type and tends strongly to ankylosis. The amount of pain suffered in the joint last affected is usually less than that of the first joint, probably because there is less jar or motion when two hip-joints are affected than when one alone is attacked.

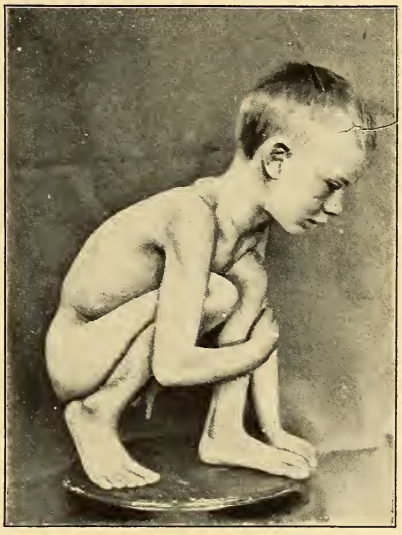


FIG. 102.—Progression in a Case of Severe Double Hip Disease.

Malpositions are more than usually troublesome and may be different in the two hips. Recovery without deformity and with as much motion as possible is most important in double hip disease.

DIAGNOSIS.

The diagnosis of hip disease may be easy or difficult;[1] in the earliest stages errors in it are sometimes made, and care is necessary for a positive diagnosis in any stage. The most common error is the belief that the presence of pain or tenderness is necessarily present in hip disease, and that its absence excludes the possibility of hip disease. Another error often made is to look for "grating" in the joint as a sign of the disease. That sign is to be obtained only by the use of an anæsthetic, by which means the muscles guarding the joint are re-

[1] R. W. Lovett: "The Diagnosis of Hip Disease." Boston Med. and Surg. Journ., August 14th, 1902.

laxed, and then only in advanced cases when two bony and eroded surfaces lie in contact.

The diagnostic symptoms in hip disease which should be borne in mind in making a diagnosis of hip disease are as follows:

1. Muscular spasm (stiffness of the joint or limitation of its motion).
2. Lameness.
3. Attitude of the limb in standing, walking, or lying (adduction flexion and abduction of the limb), and shortening.
4. Atrophy.
5. Swelling.

These symptoms vary in prominence at different stages of the disease.

It may be said that the early diagnosis must be made chiefly by the symptom of muscular rigidity and by palpation of the joint. The ab-

FIG. 103.—Method of Examining the Hip.

sence of pain or sensitiveness counts for nothing and atrophy is not significant of anything more than inflammation of the joint. The limp is peculiar, but a similar one is present in other conditions.

I. Muscular Spasm.—The chief diagnostic sign in hip disease, upon which the main reliance must always be placed, is *the presence of stiffness of the joint or limitation of its proper arc of motion* when the limb is passively manipulated. Except in the very earliest stages there can be no hip disease without a perceptible limitation of motion, unless the focus of disease is remote from the joint. This limitation of motion is

not the result of adhesions or beginning ankylosis in early hip disease, but it is the result of a tonic contraction of the muscles controlling the joint, and disappears under anæsthesia in the early stages of the disease.

In the detection of this most important diagnostic sign it should be borne in mind that some care is required to discover slight limitation of motion in very young children, who are apt to resist thorough examination. The voluntary resistance to manipulation due to fright is, however, always resistance to all motions of the limb; if by slight force this

FIG. 104.—Method of Determining the Limitation of Extension in Hip Disease.

is overcome, resistance to any especial motion will not be encountered unless hip disease is present. A comparison of the resistance of one leg with that of the other will reveal abnormal resistance. The normal amount of abduction is, however, slight, and resistance to motion in this direction, therefore, is an early test of importance. Extreme abduction

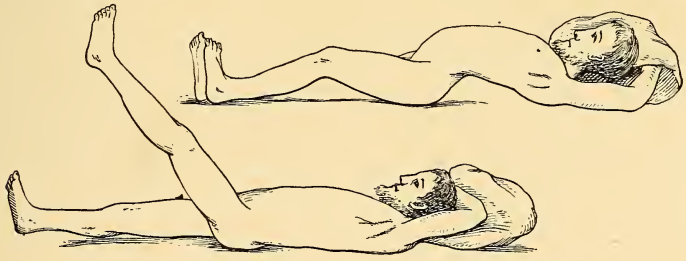


FIG. 105.—Lordosis Resulting from Bringing the Flexed Leg in Hip Disease Parallel to the Other.

and rotation of the thigh flexed at right angles to the body are tests likely to reveal the smallest degree of limited motion.

In young and frightened children the tests for limitation of motion at the hip-joint are best made with the children lying on the mother's lap or leaning on the mother's shoulder. In examining older children for muscular stiffness, the clothes should be removed and the patients should lie upon a hard surface rather than on a bed. Attempts to

move the limb should be made gradually, gently, and persistently—rough force only exciting resistance and making a delicate examination impossible. It is advisable first to put the normal leg through the same manipulations which are to be made on the affected side. The most convenient order of motion in examination is first flexion, then abduction and abducting rotation with the thigh flexed, then extension. The suspected limb should be held at the ankle or knee with one hand, while the other hand will grasp the pelvis to ascertain when motion in the joint ceases and movement of the pelvis begins. Examination under anæsthesia shows less than the examination mentioned, at the early stage of hip disease, as muscular spasm, the most important diagnostic sign, has been overcome and is absent.

If the limb is extended so that the popliteal space be placed upon the hard surface on which the patient lies, normally there will be no alteration of the position of the back; if, however, there is a limitation in the normal extension of the limb, the back will be arched up as the popliteal space is pressed down. This limitation of extension can also be determined by examining the patient lying upon the belly. If one hand be placed on the sacrum and the thighs be alternately raised from the surface on which the patient lies, a difference in the amount of motion at the hip without moving the sacrum can easily be determined. The limit to the amount of abduction or adduction is determined by placing one hand on the anterior superior spine of the ilium on the sound side, and with the other hand gently abducting or adducting the suspected limb; when limitation is present the pelvis, of course, moves with the diseased limb. For detecting limitation of rotation the thigh should be flexed to a right angle and rotation tested in that position. The motions most often limited in early hip disease are abduction, hyperextension, and rotation when the thigh is flexed to a right angle. The loss of motion in this group is always suggestive.

Careful inspection in the early stages of hip disease during manipulation will sometimes show fibrillary contraction of the muscles of the thigh, especially the adductors, on sudden or unexpected movement of the limb.

In the later stages of hip disease complete stiffness of the joint may be present. If this is due to muscular spasm it disappears, in a measure at least, under complete anæsthesia. An ankylosis of the hip-joint is as stiff under full anæsthesia as without it.

Any catch in the motion of the joint in any part of its arc is exceedingly suspicious, no matter how slight it may be.

II. Lameness.—At the earliest stages the limping may be intermittent and not constant, and, again, it may be so slight that it is practically imperceptible, so that its absence does not exclude hip disease. The diagnosis cannot be made alone from watching the child walk.

III. Attitudes.—Abnormal positions of the diseased limb at an early stage of the disease are caused by the action of the muscles holding the limb stiffly in a distorted position. Neither adduction nor abduction of the limb is usually recognized by the patient as such, but the complaint is made that the limb seems longer or shorter than the other. The pelvis is tilted, which gives a practical lengthening of the limb if abduction is present, and in the same way the limb appears shorter to the patient if adducted. The tilting of the pelvis can be recognized by drawing a line from the anterior superior spine of one side to that of the other. This should normally be at right angles with the long axis of the body. In this way have arisen the terms of *apparent or practical* shortening and lengthening, which have given rise to some obscurity, being often confused with real or bony shortening.

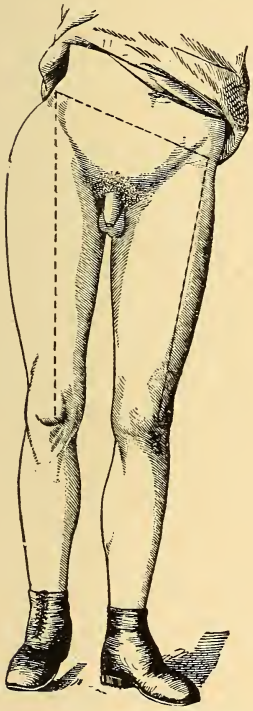


FIG. 106.—Diagram Showing Practical Shortening from Adduction.

The accompanying diagrams will explain the matter. The normal position of the pelvis in relation to the limbs is shown in heavy lines in Fig. 1, where both legs are at right angles to the pelvis, the normal position for standing and walking. If, however, the right leg is fixed by muscular spasm in an adducted position, *A E*, the relation is changed, and when the patient stands erect the legs must be made parallel to permit walking or standing on both feet, and this can be done only by tilting the pelvis to the position shown in Fig. 2. It will be seen by the tilting that the leg *A C* is carried up with that side of the pelvis, and to all appearances the leg *A C* is shorter than the leg *B D*, when the patient stands or lies straight. Thus adduction results in apparent shortening of the adducted limb as compared with the other when the patient lies straight. In the same way in Fig. 3, if the leg *A C* is abducted to the position *A F*, the pelvis must be tilted in the opposite direction to make the legs parallel, because the angle *F A B* is a fixed quantity, and so the pelvis is tilted, and *A C* for practical purposes is

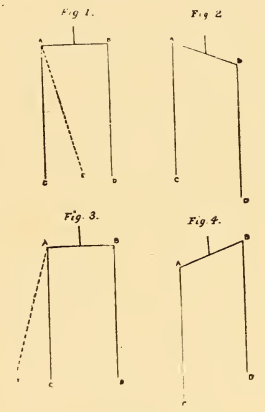


FIG. 107.—Diagram Showing Apparent Shortening and Lengthening of Leg due to Tilting of the Pelvis.

longer than *B D*, and the amount of apparent lengthening depends upon the amount of abduction.

A patient then with fixation of one leg in a position of adduction has a deformity which results in a lifting of that leg from the ground when he stands or walks, for the tilting of the pelvis has caused a practical shortening of that leg. In the same way abduction causes the opposite tilting of the pelvis and a practical lengthening of the diseased leg. So that the term apparent or practical shortening can be applied to the inequality of the legs noticed in walking or standing, which results from the tilting of the pelvis. Practical shortening can be estimated by measuring from the umbilicus to each malleolus when the patient lies or stands straight.

Real or bone shortening is different from apparent shortening. It results from the retarded growth or atrophy of the affected limb or from the destruction of bone in the hip-joint. Real shortening is measured by a tape from the anterior superior spines of the ilium to the malleolus on each side.

The amount of enlargement of the acetabulum and absorption of the head of the femur which has taken place may be estimated by determining the amount that the trochanter of the femur has risen above its normal position. If the patient lie upon the well side, and Nélaton's line (from the anterior superior spine to the most prominent part of the tuberosity of the ischium) be drawn over the affected hip, the thigh being somewhat flexed, it should pass just above the upper margin of the trochanter; if the trochanter is above this line, it is an evidence of destruction of part of the head of the femur or enlargement upward of the acetabulum.

Estimation of Adduction and Abduction.—The amount of deformity due to adduction or abduction or flexion of the limb is an important index of the progress or activity of the disease and should be carefully estimated.

A simple method has been devised by which it is possible to estimate with the tape measure alone the angle of either abduction or adduction present.

In measuring patients it is found that real and practical shortening of a leg are often not the same in the same patient, and that the difference between them varies in proportion to the amount of deformity present. This was taken as the basis for constructing the following working table. The mathematical process by which it was made is given in full in the original article.[1] To measure by this method, the patient is made to lie straight, with the legs parallel. Real shortening is measured with the ordinary tape measure, and apparent shortening is obtained in the same way. It may be repeated that real or bony short

[1] R. W. Lovett: Bost. Med. and Surg. Journal, March 8th, 1888.

ening is measured from the anterior superior iliac spines to each malleolus, and that practical shortening is found by a measurement taken from the umbilicus to each malleolus. The difference in inches between the two kinds of shortening is seen at a glance. The only additional measurement necessary is the distance between the anterior superior spines, which is taken with the tape. Turning now to the table, if the line which represents the amount of difference in inches between the real and apparent shortening is followed until it intersects the line which represents the pelvic breadth, the angle of deformity will be found in degrees, where they meet. *If the practical shortening is greater than the real shortening, the diseased leg is adducted; if less than real shortening, it is abducted.* Take an example: Length (from anterior superior spine) of right leg, 23; left leg, 22½; length (from umbilicus) of right leg, 25; left leg, 23; real shortening ½ an inch, apparent shortening 2 inches; difference between real and practical shortening, 1½ inches; pelvic measurement, 7 inches. If we follow the line for 1½ inches until it intersects the line for pelvic breadth of 7 inches, we find 12° to be the angular deformity; as the practical shortening is greater than the real, it is 12° of adduction of the left leg. If apparent lengthening is present its amount should be added to the amount of actual shortening.

TABLE I.

Distance between Anterior Superior Spines in inches.

Difference in inches between Real and Apparent Shortening.	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
¼	5°	4°	4°	3°	3°	2°	2°	2°	2°	2°	2°	2°	2°	1°	1°	1°	1°	1°
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼	..	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½	..	..	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
2¾	..	..	..	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3	..	.		42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
3¼	..	..	..	..	39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½	..	..	..	..	..	40	35	33	30	28	26	24	23	22	21	19	17	16
3¾	..	..	..	..	..	..	38	35	32	30	28	26	25	23	22	20	18	17
4	..	..	..	..	..	..	42	38	35	32	30	28	26	25	23	21	19	18

Estimation of Flexion.—The flexion deformity of the thigh may be measured by a similar method.[1] The patient lies upon a table flat on his back and the surgeon flexes the diseased leg, raising it by the foot until the lumbar vertebræ touch the table, showing that the pelvis is in the correct position. The leg is then held for a minute at that angle, the knee being extended, while the surgeon measures off two feet on the outside of the leg with a tape measure, one end of which

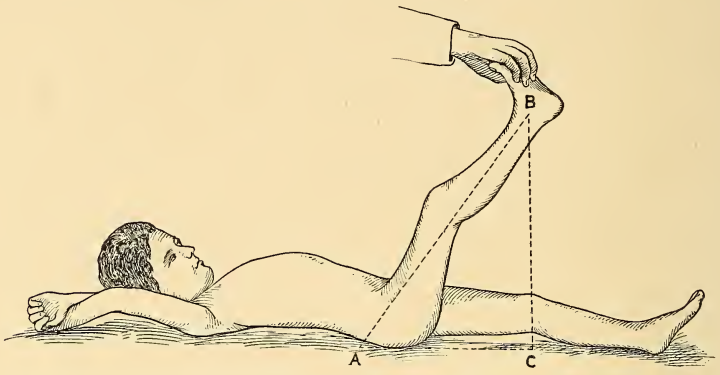


Fig. 108.—Estimation of Flexion.

is held on the table (so that the tape measure follows the line of the leg) (*A B*). From this point on the leg (*B*) where the measurement of two feet ends, one measures perpendicularly to the table (*B*, *C*), and the number of inches in the line *B C* can be read as degrees of flexion of the thigh, by consulting Table II. For instance, if the distance between the point on the leg and the table is 12½ inches, it represents 31° of flexion deformity of the thigh.

Table II.

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	63
4.0	10	10.0	25	16.0	42	22.0	67
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	39	18.0	48	24.0	90

If the leg is so short that it is impracticable to measure off twenty-four inches, one can measure twelve inches; ascertain from here the

[1] G. L. Kingsley: Bost. Med. and Surg. Jour., July 5th, 1888.

distance to the surface on which the patient is lying in a perpendicular line in the same way, then doubling this distance and looking in the table as before, the amount of flexion is found.

Thomas' test for flexion is one which is sometimes of use for a rough estimation of the amount of flexion deformity. The patient lies on the back and the well thigh is flexed on to the abdomen and held there. This places the pelvis in the correct position, with the lumbar spine in contact with the table, and the diseased thigh is by this naturally

FIG. 109.—Thomas' Test for the Estimation of Flexion of the Diseased Leg in Hip Disease.

thrown into a position of flexion if such deformity exists. It is not suitable for use in cases in which the hip is sensitive, nor, as a rule, in the case of adults.

IV. Atrophy.—Atrophy is a symptom of great significance. Its absence in real hip disease is most unusual, its presence suggestive but not diagnostic, for it exists in acute joint inflammation of any type.

The measurement for atrophy is made with a tape measure by taking the circumference of both thighs and both calves at the same level on each side. The conventional places for such measurements are at the middle of the thigh and the middle of the calf.

V. Swelling.—The existence of deep thickening over the front of the hip-joint or behind the trochanter is of great significance, and of the signs mentioned is the one least likely to be present in cases simulating tuberculous hip disease. It is not easily recognized. Thickening of the trochanter major is a diagnostic sign of assistance.

PAIN.—The significance of pain has been mentioned. "Night cries" characteristic of hip disease have already been mentioned; they are extremely significant in pointing to the probable existence of serious joint disease, but they may exist in cases which do not prove to be real hip disease. It is no sign of the absence of hip disease when one

is able suddenly to jam the head of the femur into the acetabulum without causing pain—a diagnostic method sometimes relied on. Its violence makes it unjustifiable as well as untrustworthy.

DIFFERENTIAL DIAGNOSIS.

Some affections commonly mistaken for tuberculous hip disease in practice deserve notice.

1. **Synovitis of the hip,** of traumatic, infectious, or rheumatic origin, or from no assignable cause, may occur in children, but it presents

FIG. 110.—*X*-Ray. Femoral disease. Slight atrophy of femur and pubic bone. Erosion of head of femur. Thickening of neck of femur.

the symptoms of beginning hip disease and a diagnosis is *not* practicable in the early stages; the fact that the symptoms occur after a fall must not be allowed too much weight as arguing in favor of synovitis.

It is distinguishable from true hip disease only by its relatively briefer course. In synovitis the usual joint symptoms, such as atrophy, muscular spasm, night cries, etc., may be present.[1]

Marked thickening about the joint is less noticeable in the early stages than in hip disease.

[1] Boston Med. and Surg. Journal, cxxvii., 161.

In adults, synovitis of the hip may come on clearly after a fall; there is no history of preceding disability, and muscular spasm and wasting are present.

2. **Lumbar Pott's disease** may have for its first symptom a limp and a restriction of motion in one leg. This is due to the descent of pus in the psoas muscle or to an irritation and contraction of its fibres. As a rule, this limited motion is only in the direction of loss of hyperextension, but it may take occasionally the form of a general restriction of motion and the joint may be sensitive to manipulation. The point to be determined is whether rigidity of the lumbar spine is present; if so, Pott's disease is to be suspected. But sometimes in hip disease at a sensitive stage the tenderness of the joint is so great that on attempted flexion of the spine the erector spinæ muscles are also spasmodically contracted and lead to the appearance of rigidity of the lumbar spine. The diagnosis may sometimes be a very difficult one, and an opinion must be withheld and the case kept under observation until characteristic symptoms of one affection or the other develop. Later in the history of lumbar Pott's disease a psoas abscess will often descend and may irritate the hip-joint on one or both sides; this may again so closely simulate hip disease that it is hard to tell whether the psoas muscle is causing all the trouble or whether the hip-joint is really involved. A test of the arc of abduction of the hip may be valuable in this connection, as this motion is impaired or lost at a comparatively early stage of hip disease. It is an excellent rule never to make a diagnosis of hip disease without examining the spine to see if Pott's disease is present.

3. **Chronic arthritis deformans,** morbus coxæ senilis, which in many cases remains purely a synovitis without ostitis, begins sometimes idiopathically without the history of even slight injury. A diagnostic point relates always to the age at which the patient is attacked, it being much less common in childhood, except in extensive cases in which other joints are affected. The presence of arthritis may, of course, be demonstrated in other joints. The *x*-ray is of value in showing bone proliferation.

4. **Acute Infectious Inflammation (Osteomyelitis) of the Hip Joint.**—The symptoms are more acute than in hip disease, the swelling is greater, and the temperature higher as a rule. In young children the diagnosis is often obscure until operation is required by abscess. In König's collection of 758 cases of hip-joint inflammation there were 568 tuberculous cases and 110 of acute infectious coxitis.[1]

5. **Anterior Poliomyelitis.**—At the stage of onset of infantile paralysis there may be for a short time, in rare instances, marked pain and tenderness, with immobility of one limb; ordinarily these symptoms

[1] König: "Die spec. Tub. d. Knochen und Gelenke," pt. ii., p. 123.

are not accompanied by other symptoms of hip disease, but are accompanied by loss of power of the rest of the limb as well as a loss of its normal warmth, rapidly followed by atrophy in the whole limb. In the late stages of infantile paralysis there is no stiffness at the hip-joint, but we note abnormal mobility in all directions and other evidences of infantile paralysis, such as distortion of the foot and knee, coldness, atrophy, and marked loss of power of certain muscular groups which make an error in diagnosis very unlikely.

6. **Congenital Dislocation.**—Congenital dislocation of the hip-joint need not be mistaken for hip disease, as the clinical history of the former is of continued limp since the child commenced walking. The trochanter is above Nélaton's line. There are no symptoms of muscular stiffness or limitation of motion of the hip in congenital dislocation; in fact, no symptoms of hip disease except the limp in gait. Patients with congenital dislocation, however, at times have slight attacks of synovitis of the hip due to the imperfect mechanism of the joint, but these symptoms subside after a short rest.

7. **Hysterical joint affections,** as they are to be diagnosticated from organic joint disease, will be considered more fully under the head of functional joint disease. It may be said here that the symptoms of functional and organic hip disease may be much the same, the characteristic of the former being that they are variable in their intensity and not consistent with one another.

8. **Coxa vara,** a distortion of the neck of the femur, gives rise to shortening and limping. The trochanter is higher than Nélaton's line. There is either good motion at the hip-joint or the limitation is in the direction of abduction, while the flexion is free. The amount of limitation of motion is less than would be expected from the history of the case, which is of long duration. The diagnosis is aided by a skiagram.

9. **Knee-Joint Disease.**—Hip disease is often diagnosticated as "knee trouble," so that it seems worth while to call attention to the well-known fact that pain in hip disease is in most cases referred to the inner side of the knee. Examination will show which affection is present.

10. **Miscellaneous Conditions.**—Perinephritis and appendicitis have been mistaken for hip disease. Such an error, however, must be rare. In the chronic forms of these affections there may be slight psoas contractions and the presence of iliac abscesses. In these affections the limitation to motion of the thigh at the hip-joint is not general nor does it affect abduction, but it is most marked in the direction of limitation of extension.

Periarticular disease, which has not yet attacked the joint or the epiphyses of the joint, is recognized with difficulty. Under the

head of periarticular disease may be included inflammation of bursæ and lymphatic glands, psoas abscess, or psoas muscular spasm from caries of the lumbar spine (psoitis).

Sarcoma of the hip may be mistaken for hip disease or hip disease for sarcoma. The *x*-ray may give assistance in the diagnosis and a piece of the growth should, of course, be removed for examination.

Separation of the Epiphysis of the Femur.—Separation of the epiphysis or fracture of the neck of the femur, with the resulting distortion, which may be termed traumatic coxa vara, can be distinguished from hip disease by the history aided by an *x*-ray examination.

PROGNOSIS.

Under favorable surroundings the disease is one which tends to recovery in a majority of cases with more or less deformity. It is the duty of the surgeon to see that the chances of recovery are as favorable as possible, and when recovery occurs that it shall result with the least deformity and the most useful limb possible.

Mortality.—The rate of the mortality due to the disease in hip disease is greater among the poorly nurtured hospital cases than where after-treatment can be carefully looked after.

Cazin[1] reported, in 80 cases of suppurative hip disease treated at the hospital at Berck, in the course of five years, 55 per cent were cured; 12.5 per cent died; 25 per cent were not cured; 7.5 per cent were improved when removed. Of 288 cases collected by Gibney there was a mortality of 12.5 per cent from exhaustion, meningitis, and amyloid degeneration. In the Alexandra Hospital, London, there were 100 deaths out of 384, a mortality of 26 per cent; of these, 260 were suppurating cases, and the death rate of these was 33.5 per cent. Forty-two per cent were reported cured. C. F. Taylor, of New York, has reported 94 cases in private practice, with only 3 deaths; of these 94, 24 were suppurating. Hueter reports the mortality of hospital cases at 27 per cent, and Billroth at 31 per cent. Jacobson reported a mortality rate of 73.2 per cent in 63 suppurating cases. The mortality rate from the disease alone has been generally considered to be about 30 per cent. Shaffer and Lovett investigated 51 cases of cured hip disease which had been discharged from the New York Orthopedic Dispensary at least four years previously, and found that 41 had remained cured. Of the remaining 10, 4 had died and 6 had relapsed, although 4 of the latter had been apparently cured a second time.[2]

Causes of Death.—Death may occur from (1) the generalization of tuberculosis in the form of phthisis, tuberculous meningitis, and gen-

[1] "Statistique des Coxalgies suppurés," Bull. de la Soc. de Chirurgie, No. 5, 1876.—Shaffer and Lovett: N. Y. Med. Journ., May 21st, 1887.

[2] N. Y. Medical Journal, May 21st, 1887.

eral tuberculosis; (2) from amyloid degeneration of the viscera; (3) from exhaustion; (4) from intercurrent disease; (5) from septicæmia and exhaustion after suppuration.

Functional Results.—Spontaneous cure may result in hip disease, but as a rule with little motion and with marked deformity.[1]

Recovery with complete motion after tuberculous hip disease is rare, but occurs even in hospital cases. From this condition to complete loss of motion the cases range according to the thoroughness of treatment, the severity of the disease in the individual case, and the resistance of the child. The earlier that treatment is begun the better

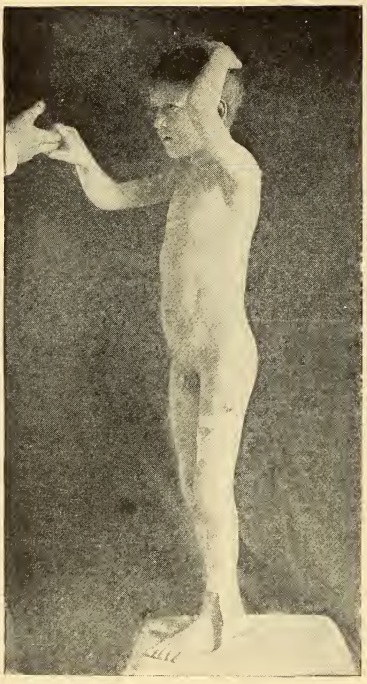


FIG. 111.

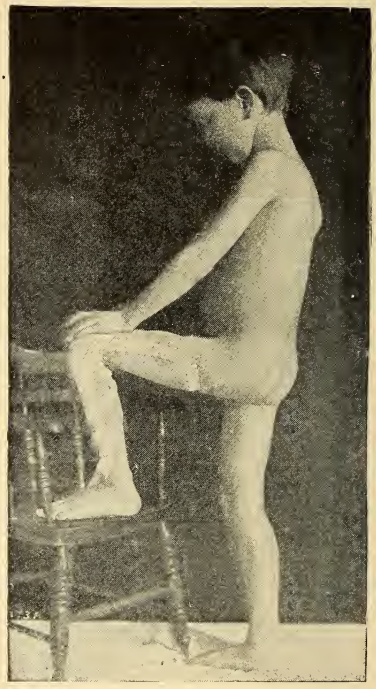


FIG. 112.

FIGS. 111 and 112.—A Case of Hip Disease under Ambulatory Treatment. Result good. Motion to right angle. (Children's Hospital Report.)

the outlook. A cure by ankylosis would be expected by the writers in perhaps a quarter or a third of hospital cases who followed out treatment properly. Some amount of motion would be expected in the majority of cases. The amount of joint motion is likely to diminish rather than increase in the years following treatment.

The prognosis in hip disease in adults is less favorable than in children, as the process is generally of a severer type.

[1] New York Med. Rec., March 2d, 1878.—Trans. Am. Orth. Assn., vol. xi., p. 256.

If a cure with ankylosis takes place, an important practical point, as regards the use of the limb and locomotion, is the position in which ankylosis occurs.[1]

Length of Time for Treatment.—It may be stated that at least from two to three years will probably be needed in the treatment of a case of hip disease taken at an early stage, while protection to the joint will be advisable for two or three years more.

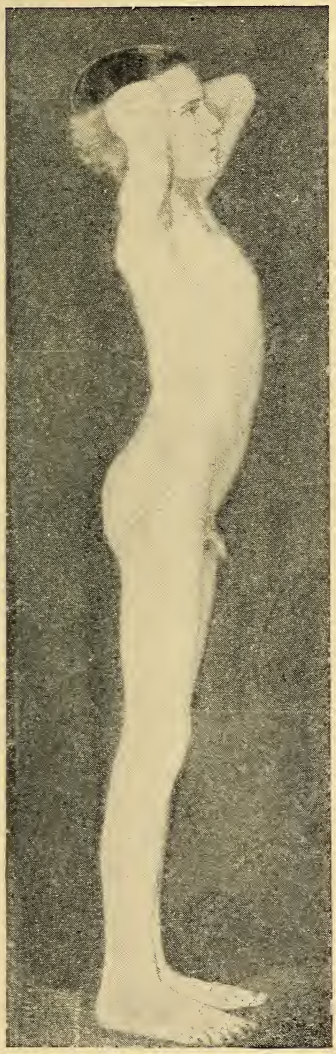


FIG. 113.—End Result in Patient with Hip Disease under Traction Treatment. Traction two and one-half years. Trochanter on Nélaton's line (see Fig. 114).

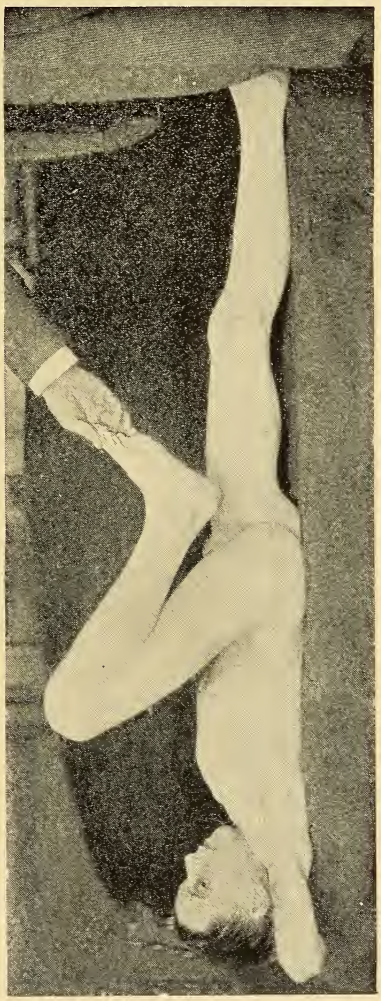


FIG. 114.—End Result in Patient with Hip Disease under Traction Treatment. Traction two and one-half years. Trochanter on Nélaton's line.

The early discontinuance of treatment is a serious mistake, as re-

[1] N. Y. Med. Record, March 2d, 1878.—British Med. Journ., August 3d, 1889.

lapses are likely to occur when everything seems quiet. In the same way too early a discontinuance of the convalescent splint will often cause trouble. It is therefore much safer to err on the side of keeping on an apparatus unnecessarily long than to run what would seem to be a considerable risk of relapse. Even when a relapse does not occur, the too early discontinuance of treatment may lead to an increase in the flexion or adduction deformity.

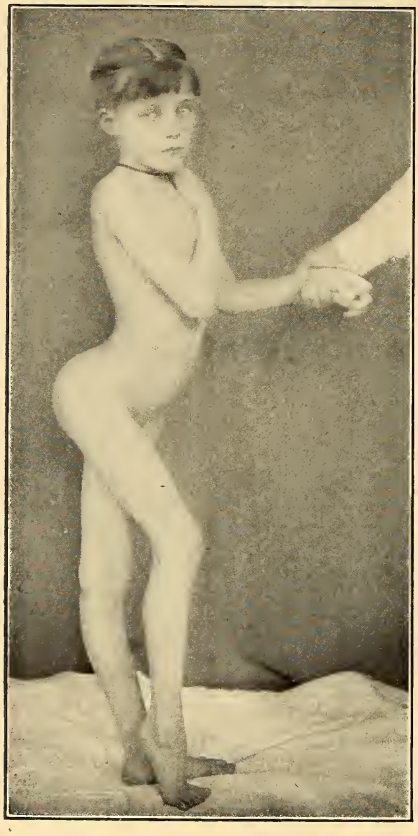


FIG. 115.—Cured Case with Marked Permanent Flexion, showing Lumbar Lordosis.

Distortion.—The prognosis as to distortion, however, does not necessarily imply permanent distortion; for at the present time, after recovery from hip disease (the deformity still existing with severe flexion and adduction) these disfigurements can be entirely and permanently relieved by subtrochanteric osteotomy. It is, however, much more desirable to correct malposition of the limb whenever it occurs than to allow it to become permanent, when its correction is a much more serious matter. The prognosis as to lameness will depend on the amount of malposition of the limb, the amount of motion present, and the degree of shortening.

Shortening.—Some *shortening* will be present in a majority of cases if the disease continues for any time, but for practical use in locomotion the actual shortening is of much less moment than the position of the limb. At the close of the disease an average amount of shortening would be from half an inch to two inches, if one considered the severer cases. There may be no shortening, but if the head of the femur is dislocated it may be a shortening of from three to five inches.

Actual shortening due to arrest of growth of the limb is beyond the control of the surgeon; but shortening from subluxation or dislocation of the head of the femur or enlargement of the acetabulum may be said to be due to a lack of thoroughness of treatment by traction. Perfect treatment may in some instances be impossible, from circumstances

beyond the control of the surgeon; but he should persistently bear in mind that subluxation and distortion from that source can be prevented by thorough treatment of the disease.

Atrophy is never entirely cured in severe cases, but in the calf muscles it diminishes very much after the use of the leg is resumed.

Abscess.—The significance of abscess is not very great; it does not affect the ultimate amount of motion in the joint nor does it seriously increase the shortening.[1]

When abscesses occur in cases under careful mechanical treatment, the outlook is worse than in suppurative hip disease in general, because the careful treatment prevents the occurrence of abscess in all but the worst cases, so that in these the death rate is necessarily high. In a series of 63 cases of abscess from the Boston Children's Hospital,[2] the death rate was 40 per cent. Abscess occurred in 18.7 per cent of 574 cases of hip disease under out-patient treatment which were analyzed.[3]

The amount of sensitiveness of the hip and pain in cases which are well treated should be slight, though nocturnal cries may persist for a while in the early stages. The reoccurrence of night cries late in the disease, or of acute sensitiveness of the joint, is most often a sign of inadequate treatment or of trouble coming in the joint; most frequently it precedes the occurrence of abscess.

Under conservative treatment *carried out for a sufficient time* one may expect a good functional result in the majority of cases. In few diseases is the benefit of thorough, skilled, and long-continued treatment more clear, and in few surgical affections can the surgeon attempt to check the progress of disease and influence recovery with greater probability of success than in hip disease; but the surgical care and supervision should not be limited to the more acute stages of the affection, but should be continued during the convalescent stage if the best results are desired.[4]

TREATMENT.

General Considerations Influencing Treatment.

It is to be remembered that the hip-joint differs from the other joints in that it is surrounded by strong muscles. These, in case of acute inflammation of the joint, develop a condition of exaggerated irritability analogous to the blepharospasm in ulceration of the cornea. This condition needs surgical consideration, as unless checked it will

[1] Shaffer and Lovett: Loc. cit.

[2] Boston Med. and Surg. Journ., November 21st, 1889, p. 503.

[3] Lovett: "Dis. of Hip," p. 117.

[4] The report of certain representative cases, with the results obtained in them, will be found in the second edition of this book, p. 241. They are omitted in the present edition as unnecessary.

develop deformity and destruction of the joint. The means at the surgeon's disposal besides operative measures may be classed as means of fixing the joint, distracting the joint, and protecting it from injury, and involve a consideration of methods of (1) fixation, (2) traction, (3) protection.

The treatment of tuberculous ostitis of the hip-joint is based upon the same principles that are of importance in the treatment of tuberculous ostitis of other joints, modified by the special anatomical conditions of the hip.

The Principles of Treatment by Fixation and Traction.

The object of fixing any joint affected with ostitis is to prevent an aggravation of the inflammation of the bone by the injury incident to motion. In an acutely inflamed condition the slightest motion involves joint injury and is to be avoided while the acute stage persists. In many joints it is necessary merely to secure firmly the bones forming the joint, and injury to the joint is prevented. In the hip-joint, however, two factors militate against the efficiency of the ordinary methods of fixation:

1. The difficulty met in securing the upper portion of the joint, viz., the pelvis, which, owing to the mobility of the lumbar vertebræ, is not secured by fixing the trunk.

2. The muscular spasm of the strong muscles about the hip-joint. These muscles are in hip-joint inflammation in a state of reflex irritability or of tonic spasm, and either crowd the head of the femur against the acetabulum by a continued muscular contraction or inflict upon the joint the injury of a sudden muscular contraction of all the muscles around the hip. The amount of this injury can be easily estimated in even the weakest of children by an examination of a cross-section of the muscles. Adults who have experienced these attacks of muscular spasm liken the sensation to that of a blow of a sledge-hammer upon the hip.

The importance in the treatment of hip disease of this increased articular pressure is shown by pathological evidence, which demonstrates the destruction of the bones forming the joint in the direction of such pressure and the absence or diminution of such destruction where this exaggerated pressure has been diminished.

The effects of traction, when thoroughly carried out, can be seen in the specimens shown in the figures.

A comparison of such specimens with those of severe hip disease in which traction was not used speaks most emphatically for the thorough use of the method.

But although these facts have been recognized, there has been a lack of exact knowledge of the amount of force necessary to counteract

exaggerated intraarticular pressure and when to apply it. To determine this, a series of investigations were made by the writers,[1] which demonstrated that in healthy joints an appreciable amount of distraction was possible in children by a traction force of twenty pounds; but in certain cases this distraction did not take place immediately on the application of the traction force, which served at first as a stimulant to the muscles. In children suffering from hip disease in the chronic suppurative stage, with disorganization of the articular ligaments, a traction force of ten pounds caused distraction. In the late stage of hip disease, when the cicatricial contraction of the capsule and tissues has taken place, distraction is not effected by a traction force. In suppurative cases of hip disease with extensive disorganization of the cotyloid ligament, a slight traction force of a few pounds causes distraction. This can be easily demonstrated when a joint disorganized by hip disease is cut down upon and the finger inserted into the joint. Although under attempts at fixation of the hip-joint without traction the violence of the spasm of the muscles of the hip-joint diminishes, it is impossible to prevent entirely injurious muscular spasm without traction, and it will also be found that cases treated by so-called fixation alone will mean a greater danger of pressure destruction of the head of the femur and wandering of the acetabulum than when traction is efficiently applied.

It would appear that no thorough fixation of the inflamed hip-joint is possible without traction, and that when a patient is suffering from an acute condition of tuberculous ostitis to such an extent that all motion is injurious, it is also necessary to provide for protection of the joint from injurious muscular spasm.

The consideration of the treatment of hip disease for practical purposes may be divided into: A, The treatment of the acute stage; B, the treatment of the subacute stage; and C, the treatment of the convalescent stage.

A. The Treatment of the Acute Stage.—Treatment at this stage demands arrangements which will prevent movement of the joints and pressure from muscular spasm. To prevent movement of the hip-joint, the ordinary gas-pipe bed-frame (Chapter XXI., **9**) already described will be found of practical value. The child is placed upon the back upon this frame, and the shoulders, pelvis, and unaffected leg are secured by means of straps. Traction is then applied to the length of the leg by a pulley attached to the foot of the bed. This pulley is arranged in such a way that it pulls upon the diseased leg in the line in which it is held when the pelvis is placed square upon the frame. If flexion is present the pulley is elevated, and if adduction or abduction is present the leg is pulled in or out. If the leg is pulled in a position of flexion,

[1] Children's Hospital Report, 1898.

it is held in position by an inclined plane or by folded sheets placed under it. The amount of traction force to be used is a question of judgment in each case, but as much weight should be applied as can be borne without discomfort by the patient. The foot of the bed should be raised to furnish counter-traction. If the patient is too sensitive to be placed upon the bed-pan without discomfort, a hole should be cut

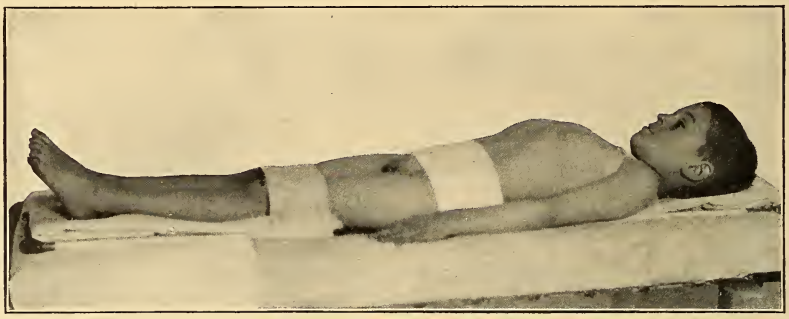


FIG. 116.—Method of Securing Child to Bed Frame for Recumbent Treatment of Hip Disease without Deformity.

in the covering of the frame to allow the bed-pan to be placed under the frame without disturbing the patient. The patient should be turned once a day to have the back rubbed with alcohol, and this should be done with extreme care. Traction should be made upon the leg

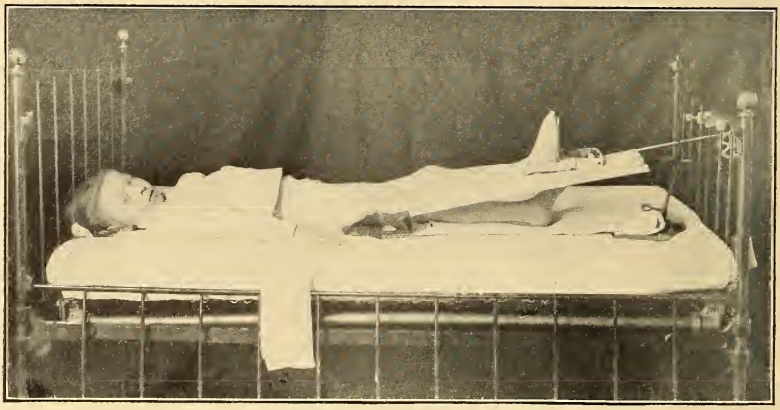


FIG. 117.—Traction by Inclined Plane.

when the patient is turned and the hip-joint should not be moved during the process. In cases in which traction efficiently used does not afford relief, lateral traction may be added. This is furnished by means of a cloth band passing around the inner side of the upper part of the thigh which runs straight out, and is attached to a weight hanging over the edge of the bed. Resistance to this pull is furnished by

another cloth band running around the ilium on the diseased side, passing around the patient, and over the other side of the bed to be attached to another weight. The amount of these weights is to be determined by the comfort of the patient. Traction during the acute stage may also be furnished during recumbency by the application of a long traction splint, which is used in place of the weight and pulley traction. In this case the patient lies upon the bed-frame wearing the traction splint. The use of the weight and pulley during recumbency without the use of the bed-frame is ineffectual, as the patient lies upon a sagging mattress and fixation is not afforded to the diseased hip.

B. The Treatment of the Subacute Stage.—During the subacute stage of the disease it is desirable that the patient should go about as

FIG. 118.—Lateral Traction in Hip Disease.

far as is compatible with the welfare of the diseased hip. The most efficient mode of treatment during this stage is to be found in the use of the traction splint, which furnishes not only traction, but also some restriction of motion. Unrestricted activity is not desirable at this stage. The patient's day should be a short one, broken by a period of recumbency. While wearing the splint the patient should sleep upon the bed-frame arranged in the manner described in speaking of the acute stage of the disease.

TRACTION SPLINTS.

Traction splints exert their power upon the joint by virtue of pulling down the leg against a counter-point of pressure furnished by the perineum. A number of appliances have been devised for the purpose of traction, the principle of which is practically the same, viz., perineal resistance with a pulling force exerted on the limb.

The traction splint (Chapter XXI., **10**) in common use is developed from the traction splint originally devised by Dr. Henry G. Davis. The modifications by Dr. C. F. Taylor and Dr. L. A. Sayre were, however, of great importance in establishing the usefulness of the appliance. A traction appliance consists of an outside steel upright reaching from the trochanter to below the foot; at the upper end is a horizontal rigid pelvic girdle in which the patient is secured by one or two perineal straps; to the bottom of the shaft is attached some appliance for exercising traction upon the limb, the latter being held to the bottom of the splint by means of webbing attached to adhesive plaster straps.

The adjustment of traction is easily provided for in several ways. One is by means of a sliding rod moving within a tube, the extension of the splint being controlled by means of a key and ratchet, a catch securing the rod when in the proper position.

The lower end is furnished with a broadened piece, bent so as to pass under the foot, and straps are attached to it which can be buckled into buckles secured to the adhesive plaster on the patient's leg.

A cheaper arrangement for traction can be furnished by means of a small windlass on the footpiece of the splint, turned by a key with a ratchet.

Perineal Bands.—These may be made of webbing covered with Canton flannel or chamois skin. Leather sewed smoothly around a leather strap is the cleanest perineal band of all; but in the hands of careless persons it becomes hard with the constant wetting from urine, and is liable to chafe.

Two perineal bands are better than one, as furnishing better counter-resistance to traction and checks to adduction of the limb.

The perineum should be kept powdered, and it should be bathed in alcohol daily. When an excoriation appears the perineal band should be covered with linen which is well spread with vaseline or zinc ointment and changed often. If the chafed spot becomes worse, the perineal band on that side should be removed and the other band entrusted with the whole weight; or the child should be put to bed, the splint removed, traction by means of a weight and pulley in bed being used for a short time until the perineum is healed. Ordinarily, with proper care and cleanliness, the perineum is able to bear after a short time all the pressure needed.

Traction Straps.—The readiest way to obtain the hold upon the limb for an extending force is by means of adhesive plaster applied as indicated in the diagram. It should be applied firmly to the thigh above the knee. If applied to the leg alone, traction falls upon the knee and may cause relaxation of the ligaments of that joint. Efficient plaster should be used, of a kind that will adhere readily without being heated. A plaster prepared with a combination of oxide of zinc will be found

to irritate the skin less than the ordinary surgeon's adhesive plaster. The plasters should be changed every three or four weeks, or oftener if they cause irritation. They can readily be removed, if the skin and plasters be thoroughly moistened with benzin or ether. If any portion of the limb is chafed by the plaster, it may be protected by means of a

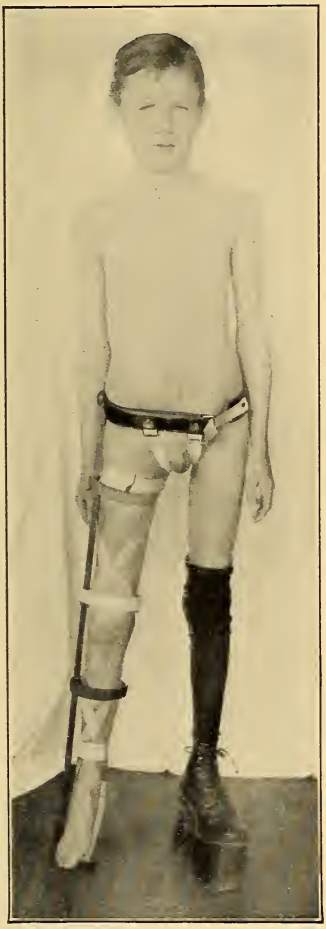


FIG. 119.—Traction Hip Splint Applied, Front View.

FIG. 120.—Traction Hip Splint Applied, Back View.

cloth covered with ointment placed over the part, and the plaster be applied over the cloth and the whole limb; or if the chafing is extensive, the whole limb can be covered with zinc ointment and protected by a smooth bandage, and the plaster put on over the bandaged limb. This will require frequent renewal, but will answer temporarily. A bandage applied over the plaster impedes the circulation and increases

the danger of eczema or chafing. If a bandage is applied over the plaster and worn for a few hours after it is first put on, sufficient adhesion of the plaster will be secured if proper plaster is used. In certain cases an obstinate eczema is occasioned by the adhesive plaster, and it

FIG. 121.—Traction Hip Splint Applied, Side View.

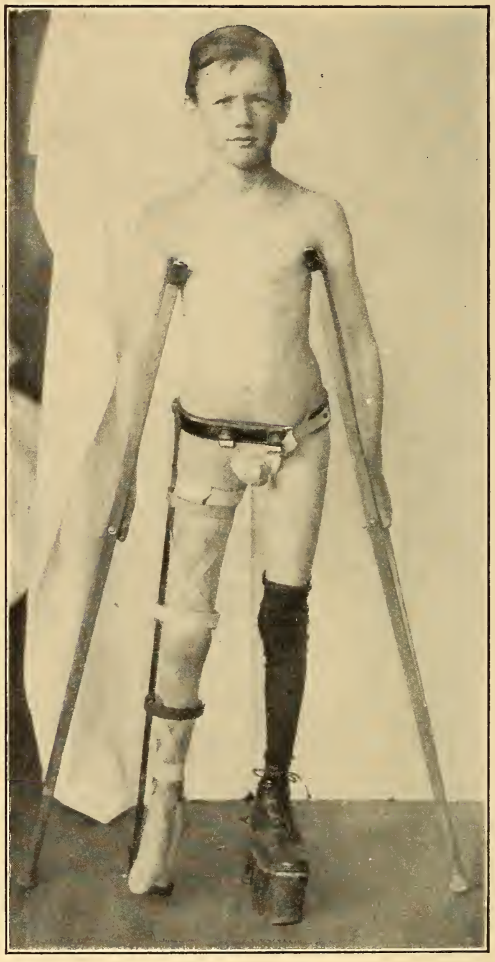


FIG. 122.—Traction Hip Splint, High Sole and Crutches Applied.

is necessary to have recourse to some other means of extension. Substitutes for plaster are to be found, gaiters applied to the ankle or straps above the knee. These, however, will slip if more than a slight traction force be applied, and are not as a rule satisfactory. Another form of traction strap can be made in the following way: Cloth is cut

to fit the thigh and leg accurately; webbing straps and buckles or lacings are attached, which when tightened give a hold upon the thigh above the knee. If straps are sewed to this leather or cloth legging, they can be made to furnish fairly efficient traction; but they are likely to slip, and are inferior to the simple adhesive plaster as a means of traction.

Application and Use of the Traction Splint.—The traction splint is applied by having the child lie on the back while gentle traction is made on the leg by the hand to steady it. The pelvic band is passed around the child, buckled around the waist, and the perineal bands are fastened. The traction straps below the foot are then attached

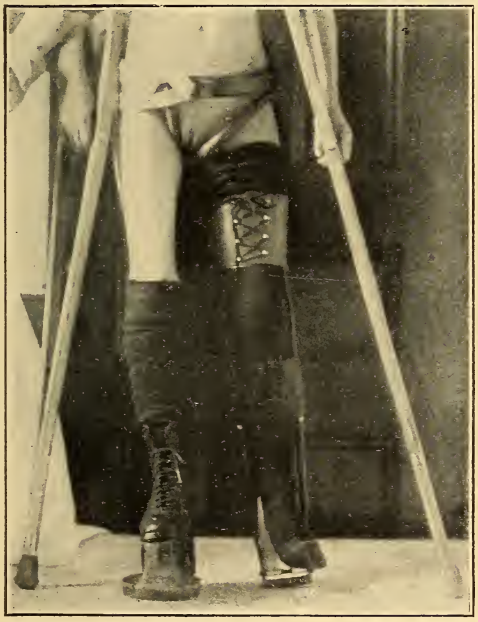


FIG. 123.—Double Upright Hip Splint Applied. (Dane.)

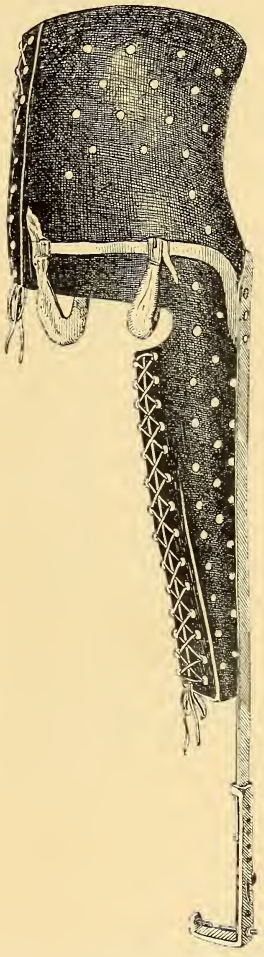


FIG. 124.—Leather Spica Traction Splint.

to the windlass or whatever extending apparatus is used, and as much traction applied as the child can comfortably stand. The straps around the leg are then fastened. When it is necessary to remove the splint or loosen the traction to care for the perineum, traction should be made upon the leg by the hand.

Crutches.—With an efficient traction splint thoroughly applied, a sufficient amount of restraint of motion at the hip-joint can be furnished

to enable a patient not in the acute stage of the disease to move about with the aid of crutches, the well limb being elevated by a raised shoe. In cases with any tendency to acuteness, however, thorough traction is essential, and walking on a traction splint without crutches is liable to cause perineal chafing and less efficient traction, as at each step on the splint the traction force is somewhat diminished, on account of the yielding of the perineal straps. In cases in which convalescence has been established, crutches may be dispensed with and less traction exerted.

Modified Traction Splints.—Various modifications of the traction splint have been made, in the hope of securing greater fixation in connection with the traction and in this way to enable free locomotion without endangering the joint. The splint devised by Dane (Chapter XXI., **12**) and the combination of the traction splint with a plaster or leather spica represent the most efficient forms of this apparatus. The objection to such appliances is that they neither fix the joint nor do they permit as efficient traction as that furnished by the traction splint without a modification. The arm extending up to grasp the pelvis or thorax acts as a lever which jars the hip as the trunk moves, and the greater the traction used the more injurious is the lever action.

A plaster-of-Paris bandage over the trunk and affected limb (as far as the knee), over which a traction apparatus is applied, the traction straps being placed on the limb before the plaster bandage is put on, furnishes probably the most effective combination of traction and partial fixation. Less cumbersome than the plaster, but not as easily furnished, is a moulded leather spica splint made over a cast by a similar process of manufacture to that described in speaking of leather jackets (Chapter XXI., **3**). Still another arrangement can be furnished if a cloth corset with lacing be made, enclosing the trunk and limb and attached to a Thomas hip splint (Chapter XXI., **13**). If this is laced snugly to the patient the child can be lifted with but little jar to the hip, and a traction splint can be applied with but little additional difficulty. This combination is of service in exceptional cases in which the acute stage is longer than usual, but it is not necessary in ordinary cases in which a comparatively short thorough treatment by recumbency is followed by a subacute stage where the limitation to the hip motion is furnished by a well-applied traction splint.

Fixation Splints.

Ambulatory treatment by means of so-called fixation appliances without traction has been tried in many cases for many years at the Boston Children's Hospital. The results in comparison with those obtained where traction was efficiently and carefully applied to similar cases justify a strong statement as to the superiority of the em-

ployment of traction in the subacute stages of hip disease, not only on theoretical grounds, but because of the superiority of the results obtained as observed in a large number of cases carefully treated and carefully recorded.

Ambulatory treatment by partial fixation without traction may be needed when but little nursing care can be furnished, and the surgeon should be familiar with the best methods of its employment. It is manifest that thorough hip fixation cannot be given if the patient is allowed to move about, as the pelvis cannot be thoroughly secured by any bandage or appliance. It is also true that the method, although imperfect, is better than no treatment. Through its use patients may be relieved of the acute symptoms.

Plaster-of-Paris Splint.—The hip-joint may be fairly well immobilized by a plaster-of-Paris spica reaching from the axillæ to the heel.

FIG. 125.—Application of Plaster Spica Hip Bandage.

It is made more efficient if the other limb is included by a double spica, which, however, prevents locomotion. With a bandage applied to one leg alone the patient can go about on crutches wearing a high shoe on the other foot. This forms the routine of treatment in many European clinics, but the amount of effective fixation furnished is limited. The aim of this treatment is well expressed by a representative French surgeon writing as follows: "It is ankylosis in good position that we pursue as the ideal of a cure in coxalgia."[1]

What has been said of the plaster-of-Paris spica, even when so applied as to hold the thorax and the other leg, is true of metal and leather splints, which do not so completely hold the joint as that does. These lack fixative power by virtue of the little hold which they have upon the pelvis, and although in many cases of hip disease they serve a

[1] "Late Excision of the Hip." Boston Med. and Surg. Journ., July 1st, 1897.

therapeutic purpose in acting as an incomplete means of fixation, they cannot be advocated for general use.

The Thomas Splint.—The Thomas hip splint (Chapter XXI., **13**), invented by H. O. Thomas, of Liverpool, is an appliance much in use in England. It is a very simple apparatus, easily made, and having many points of usefulness. It consists of an iron bar extending down the back of the body and the diseased leg to a little above the ankle; the upper end of this is attached to a chestpiece which is at right angles to the upright and encircles the chest, fastening in front. There are two circlets of iron which grasp the thigh and calf. The appliance is kept in place

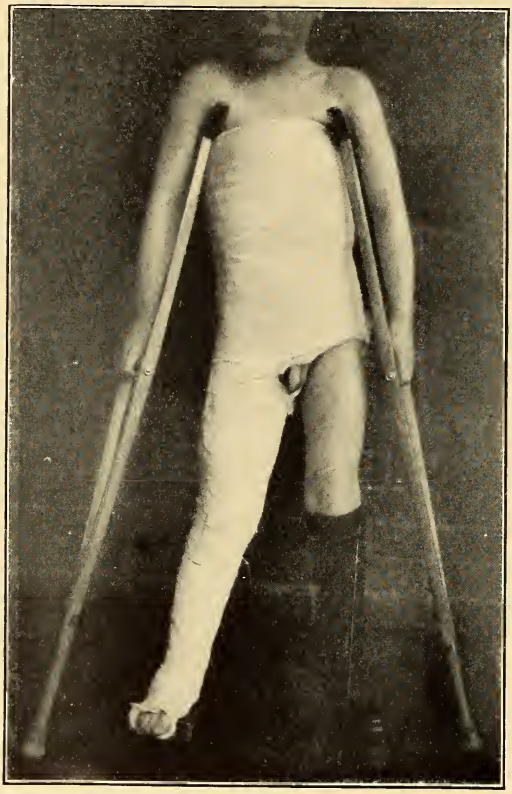


FIG. 126.—Plaster Spica Hip Bandage.

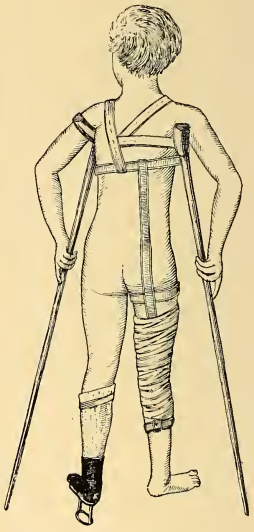


FIG. 127. — Thomas' Splint Applied, Posterior View. (Ridlon.)

by a wide chest band and a bandage around the limb, and can be bent to fit any degree of flexion existing in the diseased leg and applied to it in that position. The apparatus requires much skill in adjustment, as it is hard to fit and keep in place. There are two points in the use of the splint upon which Thomas laid much stress. The patient must not go about while muscular spasm and joint irritability are present, and the limb must not be disturbed even for purposes of examination unless absolutely necessary, and then only at intervals of

months. The appliance prevents motion of any great amount, enables the patient to be lifted without jarring the hip, and prevents and corrects flexion of the thigh. In certain acute cases the pain may be increased by the Thomas splint, from the fact of the imperfect fixation furnished. For motion at the hip cannot be prevented as the leg and thigh are firmly held by the flat rod to which they are bandaged, and, as this rod extends up the trunk, to which it cannot be so firmly fixed as to prevent all motion when the patient turns in bed or moves. The upper end of the rod acts as the long arm of a lever, moving with every respiration if tightly applied, and on moving jarring the hip.

A double Thomas splint is more efficient as a means of fixation, but it does not permit locomotion. In a single Thomas splint a raised patten is put under the shoe of the well foot and crutches are used.

Immobilization and Ankylosis.—Much has been written in reference to the danger of ankylosis incurred by the immobilization of diseased joints.

That fixation of a healthy joint even for prolonged periods does not cause ankylosis has been demonstrated.[1] The most common cause of ankylosis in diseased joints is, of course, in the cicatrization of the inflamed tissues. Any measure which tends to limit inflammation tends materially to limit rather than increase the ultimate impairment of motion.

Treatment of the Stage of Convalescence.—Protection of the joint from the whole or part of the jar in walking is useful in the convalescent stage of hip disease. The need of this will be readily understood if it is remembered that in ordinary walking the whole weight of the body falls upon the hip when the limb is straightened and the heel strikes the ground. A tuberculous hip may be sufficiently cicatrized to resist slight injury, while the frequent impact of a weight of upward of forty pounds may in time produce a condition of congestion which will furnish a cause for lighting up a quiescent focus of tuberculosis.

The simplest way to protect a joint is with the use of crutches, the sound limb being raised by means of a patten on the shoe of the sound limb, enabling the affected limb to swing free of the floor.

Protection Splints.

The ordinary "traction" splint, as described, can be used as a protecting splint, as it is longer than the limb and passes under the foot, enabling the weight to be borne upon the splint instead of on the patient's foot. Protection without traction (Chapter XXI., **11**) can be furnished by omitting the sliding rod, and continuing the upright rod below the foot, and expanding it at the bottom into a crutch bottom to be shod with a rubber tip running down at the outside of the foot, or

[1] N. Y. Med. Jour., May 17th, 1890.

by inserting it into a socket in the boot. The upright of the splint should be long enough that the patient's heel should not touch the sole of the boot, though the ball of the foot may do so. The greatest jar in locomotion comes as the heel strikes the ground at the commencement of the step. If this jar is broken by the splint, the remaining jar to the hip in the step will be diminished at the ankle and knee, and the hip sufficiently protected, except during the acute stages of the disease.

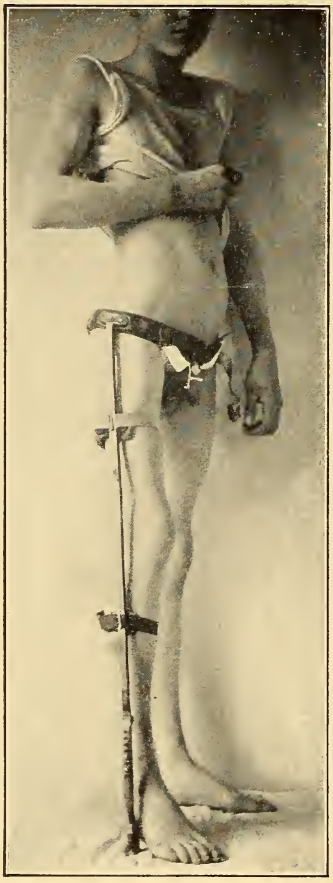


FIG. 128.—Crutch Tip Convalescent Hip Splint, Applied.

FIG. 129. — Jointed Convalescent Hip Splint, Applied.

The ordinary protection splint should be, like the long traction splint, an outside steel upright with a horizontal pelvic band at a level with the trochanter carrying perineal straps. It should be slotted below into a steel sole plate screwed to the bottom of the sole, and when the splint is in place and the perineal band buckled, the patient's heel should not touch the heel of the shoe, but hang an inch or less above it. A protection splint can be made hinged at the knee, and, if properly adjusted, patients can walk about readily with but slight discom-

fort. In this way reliable protection is secured during the long period of convalescence necessary for the thorough recovery of the affected epiphysis.[1]

If proper protection is neglected and not continued long enough, the jar of locomotion—the whole weight being thrown upon the epiphysis previously diseased—is sufficient to prolong the stage of irritability, to prevent complete cicatrization and ossification of the inflamed bone tissue, to promote contraction of the limb and distortion, and in many instances to give rise to relapses.

It is not necessary in young children that the splint be jointed at the knee in a protection splint; this is, however, of advantage in adults. As the patient's condition improves, the splint can be shortened and jar gradually be allowed to come upon the limb. Protection is needed for some years after the subsidence of active symptoms. The need for the reapplication of protection is indicated by a reappearance of stiffness or increased limping on removal of the splint. The older the patient and the more active the process the longer protection will be needed.

Relapses.—Hip disease is not ended when the acute symptoms have subsided; a process which requires so long a time for its development requires also much time for its disappearance. It is safer not to discontinue traction and begin simply protective treatment as soon as the pain and acute symptoms are gone, and it is safer not to discontinue protective treatment until a long time has been given to the joint in which to recover itself.

Termination of Treatment.—Patients apparently cured in childhood of hip disease, but with fixed or partially fixed joints, may suffer in later life from painful attacks from overstrain of the ligamentous attachments of the joints; this is especially true if any distortion remains uncorrected and the patient becomes heavy. This painful stage yields to the treatment by protection for a short time. If, however, much deformity persists, correction of the deformity is often necessary. Recurrence of the tuberculous process in adult life in a hip which has been thoroughly cicatrized since childhood is rare.

When ambulatory treatment is attempted it is desirable that every precaution against jar to the hip be taken. As it becomes clear that the danger of motion or jar at the hip has diminished, crutches can be laid aside for part of the time, with the continuance of traction as long as there is a tendency to contraction of the limb or muscular spasm. Later traction may be discontinued, but protection still maintained.

Traction should be given up only after the muscular irritability elicited by gentle manipulation has been absent for some weeks, until pain and night cries have been absent for months, and until there is

[1] "Mechanical Treatment of Hip-joint Disease." C. F. Taylor, New York; and E. G. Brackett: Boston Medical and Surgical Journal, October 6th, 1887.

every reason to believe that the process is quiescent and only partial stiffness of the joint remains, due to inflammatory adhesions and not to muscular spasm, and that protective treatment should then be pursued for two or three years at least and discontinued gradually.

Summary of Mechanical Treatment.—A systematic and graded treatment of hip disease is in this way provided, capable of meeting the successive indications in the usual course of a typical acute hip disease in its progress from an early destructive stage to recovery, first, by thorough fixation with protection of the joint from muscular spasm and traumatism; second, by locomotion with a minimum of motion at the hip and protection of the joint from jar, with a check to exaggerated intraarticular pressure from muscular spasm; and third, by freer motion at the hip, but with protection of the hip from the jar incidental to walking and a check to the development of deformity.

As cases vary, the treatment will be changed to meet the variations according to the judgment of the surgeon. The period of fixative recumbency, which should be as short as possible, will in some cases be longer than others, owing to the activity of the inflammatory process. In some cases ambulatory treatment can be begun at once without the stage of thorough fixation with recumbency. This course of treatment is inadvisable while deformity or acute spasm is present, but may be demanded by the necessity of the case. In some instances an increased risk to the local lesion may be justified to improve through greater activity the general condition.

The application of traction in hip disease to be of benefit needs to be carefully directed. As in aseptic surgery vigilance and efficiency on the part of attendants are necessary, while as in aseptic surgery a partial adoption of the method is better than its total rejection, yet the method is injurious if its imperfect use blinds the surgeon to the neglect of other essentials. A surgeon is not employing the aseptic method of treatment if he washes his hands in sterile solutions and poisons the wound with septic dressings. In a similar way the use of a traction splint in the case of a child with hip disease is not only not beneficial, but becomes injurious if it leads the surgeon to neglect the necessity of protecting an inflamed joint from undue motion.

The care required in the application of traction splints and the unsatisfactory results following apparent treatment by traction splints in out-patient clinics have led many surgeons to abandon the use of the so-called traction splints, allowing the patient to walk about with crutches, with the thigh, leg, and trunk supported by fixation appliances.

The Treatment of Complications.

Abscess.—Abscesses due to hip disease may in the early stages be absorbed in some cases under prolonged treatment by recumbency.

Abscesses may also be left to enlarge and break if for any reason this seems desirable in any individual case. If abscesses are well localized and increasing in size, and burst spontaneously, they often are thoroughly evacuated, leaving a sinus which, after discharging for some time, finally heals. Often, however, the abscess is not completely evacuated. Some residue remains, and, gravitating along the lines of fasciæ, it gives rise to the development of another abscess, until several collections of pus may be developed about the joint.

The experience of the writers in treatment by aspiration and the injection of germicidal solutions has not been favorable for the same reasons as those mentioned in speaking of Pott's disease.[1]

Incision under strict antiseptic precautions is to be advised in all cases in which absorption seems unlikely; exploration of the joint cavity should be made if the abscess communicates freely with it, and possibly softened bone may be scraped out. The abscess cavity should be examined for pockets, wiped out with dry gauze, and drained. Sinuses, as a rule, persist for months or years after operation.[2]

When efficient treatment is carried out, abscesses as a rule appear only in the severer cases, in which drainage is likely to be of benefit to the disease. The closure of abscess cavities by suture after the evacuation of their contents, while in rare instances it leads to permanent union by first intention, is not to be advised, as breaking down generally occurs subsequently. It must be remembered that the tuberculous infection is not confined to the wall of the abscess, but extends into the surrounding tissues.

Night Cries.—This troublesome complication usually disappears quickly after the establishment of thorough treatment by recumbency and strong efficient traction. It is indicative of an active condition of the process of epiphyseal ostitis. In some instances it persists for several weeks even under treatment. In such cases an abscess is usually developed. The employment of phenacetin and salicylate of soda [3] has appeared to be of some efficiency in diminishing night cries. Although opiates, chloral, and bromide of potassium in large doses will often give relief, the use of them is to be avoided if possible.

Deformity.—The deformities occurring are flexion, abduction, and adduction, or any combination of these. In the early stages of the disease when malposition occurs it is best corrected by putting the patient to bed and making traction in the line of the deformity.

Correction by the Traction Splint.—Slight cases of deformity can be corrected by the use of traction splints, which allow the patient

[1] N. Y. Med. Jour., March 2d, 1889.

[2] Boston Med. and Surg. Jour., September 18th, 1890.—Orth. Trans., vol. ii., p. 87.

[3] R. W. Lovett: Boston Medical and Surgical Journal, April, 1889.

to go about with the aid of crutches. The traction splint naturally antagonizes adduction of the limb by virtue of its pulling the leg against a counter-point in the perineum which tends to abduct the leg to which the splint is applied.

Correction by Recumbency.—In the severer cases rest in bed hastens correction. If the patient is allowed to roll about in bed, or sit up, or hold the limb flexed at the knee, it is manifest that no proper traction force is being used. It is obvious, therefore, that the patient should be fastened to a bed frame and traction made in the line of deformity. As the malposition of the leg diminishes under treatment, the line of the pull is made gradually more in the long axis of the body. The ill effect of a pulling force not in the line of the deformity in the acute stages of hip disease is evident. If an attempt is made to force the limb down in a case of flexion, and a pull be made in the line of the axis of the body, the head of the femur is crowded upward to the anterior edge of the acetabulum by the force applied at the end of the lever, viz., the femur, the contraction of the flexor muscles (holding the limb flexed) furnishing the fulcrum. In milder stages of the disease this is not so important as in the acuter stages, but it is a mechanical error in

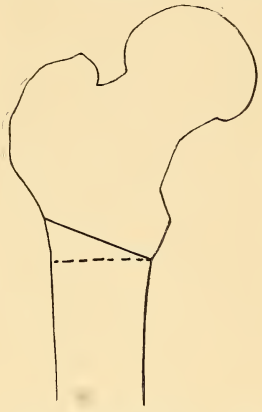


Fig. 130.—Diagram to illustrate the performance of sub-trochanteric osteotomy for the correction of ankylosis of the hip in a deformed position. The solid line indicates a linear osteotomy; the dotted and solid lines together, a wedge-shaped osteotomy.

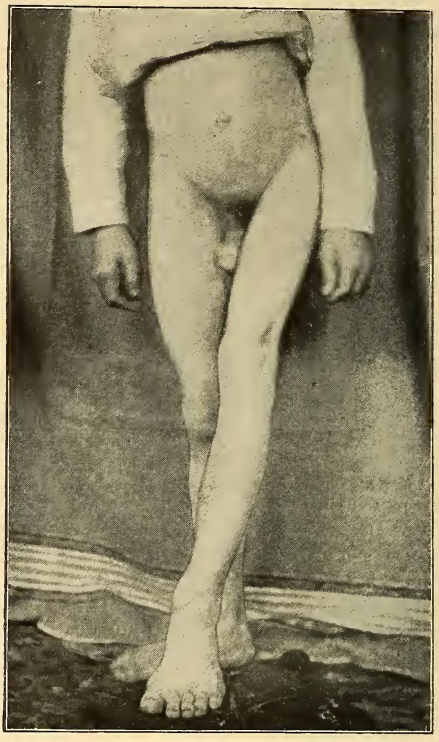


Fig. 131.—Adduction Deformity Resulting from Hip Disease before Correction. (C. F. Painter.)

any stage to attempt traction except in the line of the deformity. This error is often the occasion of increasing the pain and sensitiveness in cases of hip disease.

Correction Under an Anæsthetic.—In cases of resistant deformity treatment by traction is tedious and in the more obstinate cases ineffectual. In cases of this character the use of judicious force under an anæsthetic is advisable. Care must be exercised not to inflict a trauma upon tuberculous bone, but where resistance is firm, cicatrization of the diseased area can be supposed to have taken place, and often but little force is necessary to secure correction. Division of the contracted fascia lata and adductor muscles will be of assistance in some instances. After correction the limb should be fixed in a plaster-of-Paris spica bandage, a corrected position with slight abduction. When firm ankylosis is present manual correction will not be sufficient and recourse to osteotomy will be needed.

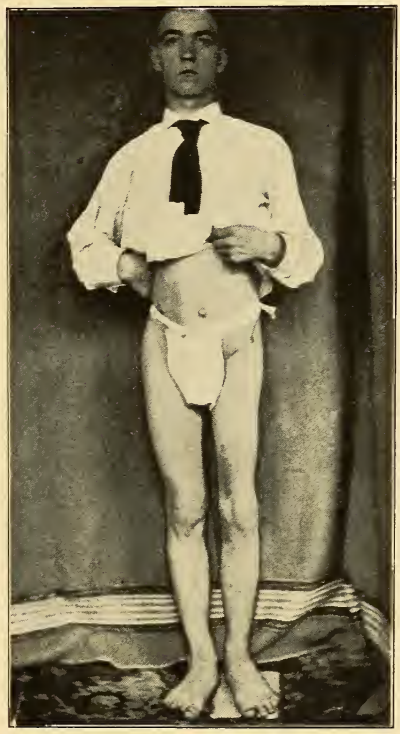


Fig. 132.—Adduction Deformity Resulting from Hip Disease after Correction. (C. F. Painter.) Same patient as Fig. 131.

Correction by Osteotomy.—The operation in common use was devised by Gant;[1] in this the femur is divided below the trochanter minor. The anatomical reasons which he gave for this step were that the resistance of the psoas and iliacus muscles was set free and that a return of the flexion was not therefore to be expected, as when the bone was divided above the attachment of these muscles. He also called attention to the fact that in operating for ankylosis, after hip disease, it was desirable, if possible, to make the section through healthy bone and as far as possible from the original seat of the disease; in this way diminishing the liability of rekindling the old joint inflammation.

Technique of Operation.—The osteotome is a chisel, which should possess a temper about halfway between that of a cold chisel and a carpenter's cutting tool, so that the edge of it will not be turned by the hardness of the bone. The cutting edge should be sharp and the width

[1] Lancet, December, 1872. p. 881.

of the blade about half an inch. The blade should be marked with a line every half or quarter of an inch from the cutting edges, so that one can tell how deeply the osteotome has penetrated. A fair-sized wooden carpenter's mallet answers better than any of the lead or steel ones found in the instrument-shops.

In the performance of the operation the patient lies on the side with a sand pillow between the legs, and the skin is sterilized carefully. The chisel may be driven in through the sound skin about an inch or an inch and a half below the great trochanter, according to whether one is operating upon an adolescent or an adult. The chisel should at first be held with the blade in the long axis of the limb and turned when it reaches the bone until its edge is at right angles to the axis of the limb. The osteotome should then be driven into the bone by sharp blows with the mallet, turning the cutting edge first forward and then backward, so as to cut obliquely through the whole shaft. If the osteotome becomes wedged it should be loosened by lateral motions and a thinner one substituted if possible. Any attempt at prying with the osteotome may result in breaking the blade and should be avoided. When the spongy tissue has been traversed by the blade of the chisel, it will come in contact with the opposite wall of solid outside bone and will at once be felt to be driven with greater resistance. Then the osteotome acts as a probe as well as a cutting instrument. The bone should not be entirely divided, but when it seems evident that only a shell is left, attempt should be made to fracture the femur—very little force is needed, and if the bone does not yield easily the chisel should be again driven in still farther—always loosening it after each blow of the mallet and directing the blade in a new direction.

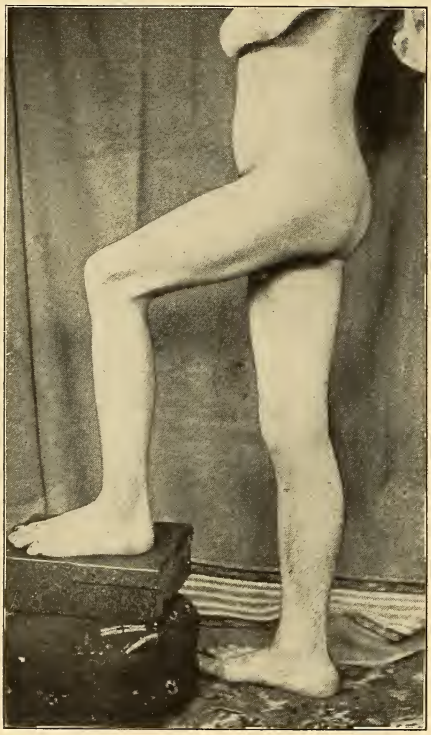


FIG. 133.—Ankylosis at a Right Angle following Hip Disease, before Gant's Osteotomy. (C. F. Painter.)

After the bone is broken, in most cases the flexed leg can be extended and the adducted one brought straight, and no unnecessary

manipulation of the bone should be made. If the osteotomy has been efficiently performed little force is needed to correct the deformity. There is little bleeding and a small skin wound, unless it is necessary, as sometimes happens, to make a cut in the anterior surface of the upper thigh, to divide bands of contracted fascia which prevent full extension of the thigh. The patient should then be fixed in a carefully applied plaster spica bandage, which should secure the hip firmly in the corrected position. The anterior spines, the patella, and the vertebral

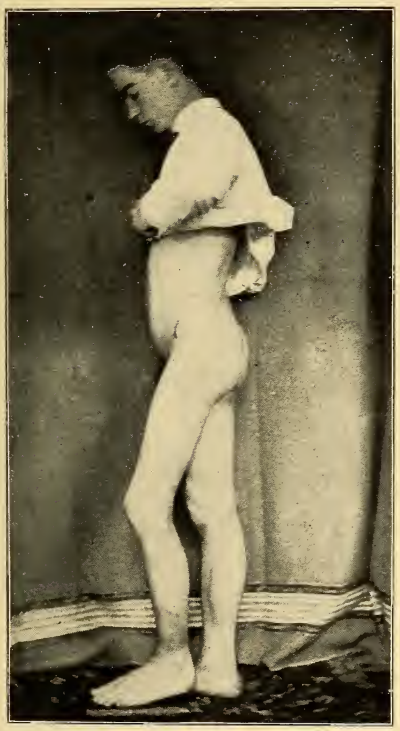


FIG. 134.—Same Patient as Shown in Fig. 133, after Osteotomy. (C. F. Painter.)

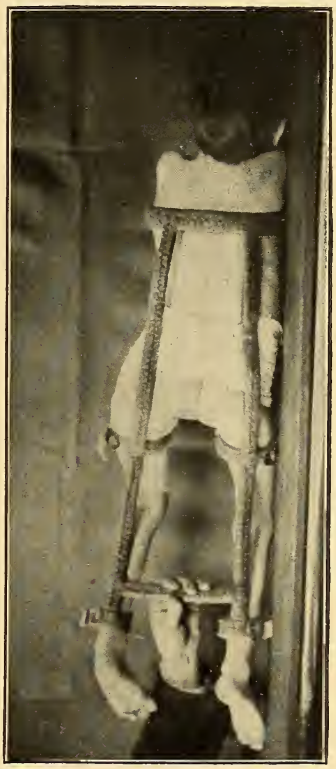


FIG. 135.—Double Thomas Hip Splint Applied.

spines should be well protected by padding to prevent sloughs. When plaster-bandage fixation is undesirable, on account of the condition of the skin, the patient should be placed on a bed-frame and a traction weight applied, pulling in the desired direction.

Confinement to bed should last between five and six weeks. If it is desired to compensate for bone shortening it can be done by putting up the shortened leg in an abducted position. The latter will be found of assistance where the shortening is great, as the resulting tilting of the pelvis adds to the practical length of the limb. The risks

attending the operation are slight. Hemorrhage is very rare—although accidents have been reported from pressure on the femoral vessels by sharp edges of bone.[1] Marked improvement in the general condition of the patient often follows the operation.[2]

After-Treatment.—After the cessation of bed-treatment, fixation in a plaster-of-Paris spica should be continued for at least six weeks more. If fixation in the improved position is abandoned too early the deformity may recur. Deformity occurring during the acute stage of the disease should be rectified as it occurs and prevented from recurring.

The ultimate functional results following the operation are excellent. Although there may be no motion at the hip-joint, the lumbar vertebræ are usually more movable than normal. The operation is indicated in all cases of severe deformity in which the distortion interferes seriously with locomotion.

Shortening of the Limb.—Shortening of the limb after hip-joint disease and after excision occurs in a certain number of cases; nothing can be done to prevent it when it is due to arrest of growth. Prevention of the development of the disease and such use of the limb as is compatible with the safety of the joint, inducing proper circulation in the limb, may be regarded as the only means at our command. The shortening due to subluxation is in a large measure prevented by efficient treatment.

Patients with much shortening of the diseased leg vary a great deal in the relief afforded by a high shoe; sometimes they find it of the greatest possible benefit, while at other times it is a constant annoyance. The shoe can be raised by a cork sole, or more cheaply by an iron or wooden patten, or by an arrangement in which the foot, like the stump of an amputated limb, fits into the socket of a specially constructed elongated boot, which conceals the shortening.

Double Hip Disease.—During the acute stage of the disease recumbency on a bed-frame and efficient traction by weight and pulley or by two traction splints is the best treatment. After the stage of spasm has passed, the patient can be carried about in a double Thomas splint and when convalescence is established, locomotion with traction or protection splints and crutches is possible. The chief difficulty in treating double hip disease is in the prevention of deformity, not so much during the active stage of the disease, but after convalescence has been established.

Deformity will probably not occur if patients are kept recumbent for a sufficiently long time to establish a perfect cure. If, however, they are allowed to walk or move too soon, before the joints are thor-

[1] Post: Ann. Anat. and Surg., January, 1883, and Rev. de Chir., December, 1881.—C. T. Poore: "Osteotomy and Osteoclasis," New York, 1884.

[2] Goldthwait: Orth. Trans., vol. xi., p. 280.

oughly strong, weight must necessarily fall upon the affected limbs in walking. If these are not sufficiently recovered to sustain the weight, deformity may ensue. Even with very little motion in either hip-joint locomotion is often possible, although the gait is necessarily restricted.

OPERATIVE TREATMENT.

Curetting and Drainage of Tuberculous Areas in Hip Disease.—In cases of tuberculous ostitis of the hip, when the process is limited to sharply defined foci surrounded by firm bone, the condition may be said to resemble that presented by an abscess, and drainage of such a focus is desirable when the part affected is easily accessible, as in the knee or os calcis. But when the acetabulum or the epiphysis of the femoral head are attacked, it is difficult to secure satisfactory drainage and the removal of all diseased tissue; nor is it, as a rule, easy in this region to determine, by means of a skiagram, the existence of a sharply defined focus. It has been shown [1] that tuberculous changes may exist in bone in an early stage of development and on the borders of apparent tuberculous cavities, and yet not be demonstrable in *x*-ray pictures taken of living subjects, especially when taken in the deeper structures. This procedure is most satisfactory when the process is situated near the trochanter, which may be trephined or tunnelled for the removal of detritus or sequestra.[2] When this is attempted for foci in close proximity to the hip-joint, it excites increased reflex irritability and exaggerated muscular spasm, and should in treatment be followed by thorough traction to overcome the injury following increased intra-articular pressure. When this cannot be provided, or when the localization of the disease is not sharply marked, the method is of doubtful value in affections of the hip-joint proper.

The operation is performed by exposing the part of the bone in which the focus has been located and removing it by thorough curetting. The cavity is then carefully dried and wiped out with strong carbolic acid and alcohol or a 2.5-per-cent solution of formalin, and the wound closed, with the exception of a temporary gauze wick. The operation should be performed with as little unnecessary traumatism to the joint as possible. The operation is followed by traction in the recumbent position.

Excision of the Hip-Joint.—This method of treatment is based upon the opinion that, when a tuberculous affection exists, repair is hastened by the eradication of the diseased portion. Excision is less to be advocated at the hip than at the knee or ankle, for the reason that it leaves

[1] Feiss: Journal of Med. Research, 1904.

[2] R. T. Taylor: Am. Journ. Orth. Surgery, vol. i., p. 232.—A. M. Phelps: N. Y. Med. Journ., September 5th, 1900.

a poor joint for weight-bearing purposes and because it is difficult and dangerous to remove the acetabulum, frequently primarily diseased in hip disease. Bardenheuer[1] has excised the acetabulum in twenty-six cases, eighteen of which were suffering from tuberculous ostitis and nine from osteomyelitis. He concludes as follows: that the complete resection of the hip-joint, including the acetabulum, is a severe but not fatal operation, though skill is required. It is indicated in all cases with septic involvement of the acetabulum and all cases of acetabular caries where conservative treatment has failed. The operation is performed by means of an incision made along the crest of the ilium, extending from the sacro-iliac synchondrosis to the anterior superior spine. The bone is to be cleared of muscular attachments down to the acetabulum. By means of a Gigli saw, the acetabulum is separated from the ramus of the pubis, the connection of the ilium, and the descending ramus to the tuberosity of the ischium. It is easier to remove the acetabulum without opening the joint, which can be opened later and the head of the femur saved. If the head of the femur is involved it is removed, being sawn off at the neck. The wound should be closed and traction applied to the limb, placed in a slightly abducted position.

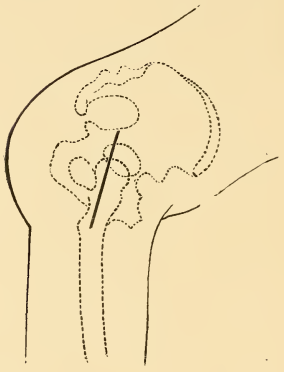


FIG. 136.—Straight External Incision for Excision of the Joint.

Excision in the early cases is not justified when conservative treatment can be carried out for a sufficient time and with thoroughness. The removal of the head and neck, moreover, removes from the socket one of the supports on which the trunk rests, and the hip is more mutilated than after the cure by the natural process of gradual absorption, repair, and cicatrization, which leaves a firm though possibly ankylosed hip. After excision the hip is necessarily mutilated. The operation is therefore reserved for the severer cases.

Method of Operation.—Of the incisions in ordinary use the straight external incision is the one most commonly used and the most serviceable.

The incision should begin at a point midway between the anterior superior iliac spine and the great trochanter, the knife being pushed directly to the bone. The cut should curve to the top of the trochanter and then downward and forward, the length of the incision being from four to eight inches.[2]

[1] Bardenheuer: Festschrift d. Akad. f. prakt. Med. in Cöln, 1904.

[2] Brit. Med. Jour., July 20th, 1889, p. 119.

The tissues should be incised down to the bone, the soft parts should be divided, and the capsule opened. It is best to incise the periosteum of the trochanter, and if possible with a periosteum elevator to free it with its muscular attachments from the bone. Sometimes the whole trochanter can be uncovered in this way.

After having made the cut down to the trochanter and separated the periosteum on the outer side so far as practicable, the next step is to separate the soft tissues from the bone on the inner side, stripping back the periosteum as far as it exists as such. In advanced cases of hip disease, however, it will be found that all that it is practicable to do is to clear the periosteum from the outer aspect of the trochanter and then to separate the muscular attachments from the neck of the bone, keeping the knife as close to the bone as possible. Then passing the finger around the femur and adducting the leg slightly will raise the head of the femur out of the acetabulum, and the capsule can then be divided and the head of the femur thrown out into sight and sawed off, or the section can be made by a small saw or osteotome before dislocating the bone if the finger is kept inside of the neck of the femur as a guard. If the head of the bone is dislocated, it is more easy to see the limit of diseased bone and to make the section well in the healthy tissue. The objection to dislocating the head of the bone before section is that fracture of the diseased and atrophied shaft of the femur may occur if it is done roughly, and also that periosteum may be stripped up from the inner aspect of the shaft and cause necrosis. When the head is adherent, it should be curetted or chiselled from its place.

The acetabulum should be examined and any sequestra removed and any carious surface should be scraped with a Volkmann's spoon. If the acetabulum is perforated, the edges should be chipped off until the point is reached where the periosteum lining the pelvis is attached to the bone.

After the operation a tube or a strip of gauze should be left in the most dependent angle of the wound and the rest may be sewed up if the tissues are not too much infiltrated with the products of inflammation. A heavy antiseptic dressing should then be applied and the hip should be fixed either upon a frame with light traction or in a plaster-of-Paris spica with the limb in an abducted position. As soon as it is practicable the child should be allowed to move about with crutches, wearing, as an appliance to prevent subsequent deformity, a traction splint.

It is impossible to remove all of the tuberculous material in excision of the hip; and this must necessarily lead to relapses and imperfect results in many cases. The mere removal of the head of the bone is a very incomplete measure for the eradication of the disease in those cases in which the tuberculous material has infiltrated all the tissues in

the neighborhood of the joint. In many cases of extensive disease it is not easy to do a subperiosteal operation. In the severer cases the capsule is lax and partially destroyed, so that the finger when first introduced in the wound finds the head of the bone only loosely in contact with the acetabulum and dislocation is easily accomplished.

The ultimate results in cases in which excision was performed only after mechanical treatment had failed are as follows:

	Cases.	Per cent of Deaths.
Children's Hospital, Boston,[1]	50	44.0
Hospital for Ruptured and Crippled, New York (Townsend [1]), ...	99	51.5

The causes of death after excision of the hip are, aside from the small per cent caused by the shock of the operation, due to the same causes as in hip disease not treated by excision, and it is certainly not

FIG. 137.—Late Excision. Poor result. No motion. Hip painful. Walks with splint. Three years since operation. (Children's Hospital Report.)

true, as has been claimed, that excision of the hip is a preventive of systemic infection. That general tuberculosis and tuberculous meningitis supervene in a certain proportion of cases of hip disease is a fact well known. Mr. Barker, an advocate of excision, in a lecture at the Royal College of Surgeons in 1888 on the treatment of tuberculous joint disease, said that in no less than ten per cent of all deaths following excision "rapid miliary tuberculosis supervened in such a way as to suggest strongly, if not to prove, that the surgical interference was the cause of the generalization of the disease."

The statistics of Wartmann, based upon 837 resections, show that at least 10 per cent of all the deaths are caused by rapid general miliary tuberculosis, coming on in such a way that it is strongly suggested that the surgical interference stood in a causative relation. This point has been of late often alluded to, and the lesson to be drawn is that in excisions the work should be done cleanly, with as little tearing of tissue and opening of lymphatics as may be, with the most careful and constant irrigation.

[1] Orth. Trans., vol. x.

Mortality.—It may be stated then, in brief, that resection of the hip-joint as an operation is attended by an immediate fatality of about 7 per cent. The mortality of the disease after the operation cannot be estimated as less than 20 to 30 per cent, and when cases are followed up for several years it is higher still.

Functional Results.—After excision of the hip-joint the mechanical conditions are not favorable to the formation of a firm joint. After operation the head of the femur is gone and part or all of the neck. The capsular ligament is destroyed, and the upper end of the femur lies loosely against the ilium—perhaps at the acetabulum, perhaps somewhere else, and out of this very uncertain contact a new joint must be formed if there is to be one, or else a union without motion. A new joint is established in successful cases.

FIG. 138.—Result of Suppurative Hip Disease Treated by Traction after Three Years' Treatment, Showing Extreme of Possible Motion.

In these cases a synovial sac may develop, and the head of the bone is bound firmly to the ilium so that a comparatively useful hip-joint remains. But the usefulness of the limb after successful excision is less than after recovery under non-operative treatment. In some instances a limb which was in excellent condition immediately after the operation becomes ultimately entirely useless. An illustration of this was reported by one of the writers[1] in a patient seen five years after excision. In Culbertson's tables[2] the case is reported as follows: "(No. 464.)—Recovered in six and two-thirds months; one-half inch shortening, almost perfect motion. Last heard from six and two-thirds months." Though the limb at the time of the patient's reported condition of cure was in a favorable condition, five years later the boy could only touch the floor with the toes of his affected limb, and was unable

[1] N. Y. Med. Jour., April, 1879.

[2] Transactions Am. Med. Assn., 1876, p. 142.

to walk without crutch or cane and could bear little or no weight on the affected limb.

It is difficult to determine definitely how large a proportion of useful limbs ultimately result in cases in which recovery has taken place after excision of the hip.[1]

In a series of 50 cases of excision of the hip done at the Children's Hospital from 1877 to 1895 it was possible[2] to report on the condition of 10, four years or more after operation. The interval ranged from four to fourteen years. One had his hip amputated later, a second was in poor general condition, but with the exception of the amputated case no one of the patients used a cane or crutch; one had 6 inches of shortening, one 5, one 4, one had 2 inches, and three had only 1 inch. The amount of motion in flexion in those of the 10 cases in which it was recorded was as follows: None, 25°, 40°, 45°, 60°, 65°, 80°.

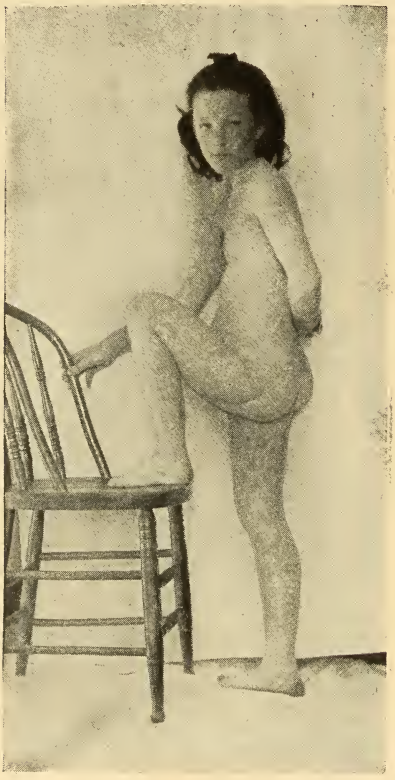


FIG. 139.—Late Excision of Hip. Motion practically perfect. (Same case as Fig. 140.)

Indications for Excision.—The indications for excision can be stated as follows:

1. When conservatism is impossible owing to lack of facilities for thorough treatment and the affection is rapidly progressive.

2. When a progressive destructive process has continued in the hip-joint unarrested by the most favorable conditions.

3. When the process is so acute that it threatens not only the destruction of the joints but endangers life.

4. When an extensive sequestrum is present.

It must be borne in mind that results as to mortality after early excisions (before extensive destruction in the bone has taken place) are

[1] Cent. f. Chir., 1879, No. 2.—Med. Times and Gaz., November 3d. 1877.—Orth. Trans., vol. vi., p. 124.

[2] Lovett: Orth. Trans., vol. x.

much more favorable than after late excision.[1] The results of careful conservative treatment, if carried out for a long time, are superior to those after excision in a majority of cases, and when conservative treatment is practicable it should be preferred. In large hospitals or among a poor and unintelligent class, conservative treatment is sometimes impracticable, and in such cases excision is resorted to earlier than would otherwise be justifiable, and the results gained are more satisfactory than when the operation is deferred. It must be evident, in comparing the mortality and the results of excision of the hip with the

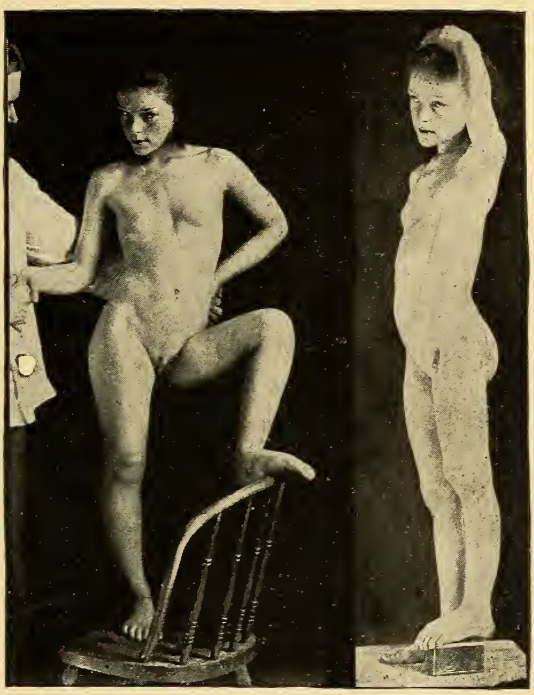


FIG. 140.—Late Excision of Hip. Motion practically perfect.

mortality and the results of conservative treatment, that excision has no place in the routine treatment of the disease, because its mortality is higher and its functional results are inferior. The operation has, however, a decided usefulness in late cases of hip disease, when it becomes distinctly a life-saving procedure, and in severe cases at an early stage when no home treatment or adequate hospital treatment for a long time is practicable.

[1] Cent. f. Chir., 1894-96.—Congrès de Chir., Proc. verbale. 481.—"Coxalgie Tuberculeuse." Paris.—Journ. de Méd. et de Chir., Annales, iv., 3, 261.—Congrès Fr. de Chir., 1895, ix., 153.—Jalaguier: Thèse d'Ag., Paris. 1886.—Archiv f. klin. Chir., xxiv., 4. 719

Although the writers have been able to gain thoroughly satisfactory results after excision of the hip, and in a few instances have had reason to regret not having resorted earlier to excision in cases in which conservative treatment proved unsatisfactory, yet after years of careful experience in the treatment of hip disease by both conservative and operative methods they would unhesitatingly record their opinion that the conservative method of treatment is preferable to the operative and that resection is needed only in exceptional cases.[1]

Amputation.—The question of amputation of the diseased limb alone remains for consideration. The mutilation which results is the chief objection to the operation, and is but partially met by an artificial limb. An undoubted reformation of bone has taken place in the case operated upon by one of the writers.[2]

Absolute economy of blood—of the utmost importance in all hip amputations—is vital in cases reduced to the physical extremity seen in cases of hip disease undergoing this operation.

The limb should be elevated and stripped of blood, and an elastic bandage is doubled and passed between the thighs, its centre lying between the tuber ischii of the side to be operated upon and the anus. A pad in the shape of a roller bandage is tied over the external iliac artery; the ends of the rubber are drawn tightly upward and outward (one in front and one behind) to a point above the centre of the iliac crest of the same side. The front part of the band passes across the compress; the back part runs across the great sciatic notch and prevents bleeding from the branches of the internal iliac. The ends of the bandage are tightened, and should be held by the hand of an assistant placed just above the centre of the iliac crest.

The danger of hemorrhage may be still further diminished by transfixing the thigh from side to side above the line of incision and securing pressure with a steel skewer passing under the vessels. If rubber tubing be passed tightly around the ends of the skewer over the anterior surface of the thigh, the front vessels can be compressed and the same method can be applied to the posterior vessels (Wyeth's method). The operation in this way can be performed without the loss of any appreciable amount of blood, and there is time for due deliberation, as there is no danger of a death upon the table by a sudden gush of hemorrhage.

The operation of amputation at the hip-joint has been performed three times at the Boston Children's Hospital in extensive disease of

[1] E. H. Bradford: "Operative Dislocation and Drainage of the Acetabulum in Articular Disease." Boston Med. and Surg. Journ., 1901, cxlv., 240.

[2] Wyeth: Ann. of Surgery, xxv., 1897, 127.—Levison: Jour. Am. Med. Assn., June 24th, 1899, p. 1428.—Erdman: Ann. of Surgery, September, 1895.—Lancet, May 26th, 1883.

the hip and pelvis, with operative success in all, but with ultimate death from amyloid disease in two cases. Ultimate recovery took place in one who grew to manhood and at twenty wore an artificial limb fitted to a stump in which reformation of the bone took place from the periosteum.

The following conclusions would appear to be justified: amputation at the hip-joint, in hip disease, should be regarded as the very last resort, contraindicated by extensive amyloid degeneration of the viscera or a moribund condition of the patient. The chances of mortality are not greater than those in amputation of the thigh in general, and the chances of a permanent cure (barring the mutilation) would appear to be greater than after excision at the hip-joint. The amputation should be done subperiosteally whenever it is possible.

Summary of Treatment of Hip Disease.

It is difficult to summarize the treatment of hip disease, for the reason that cases differ greatly in severity; some needing recumbency for a very long period, owing to a severe degree of sensitiveness or to the activity of the ostitis, while in other cases ambulatory treatment with proper appliances is sufficient without recumbency.

The proper treatment of hip disease is, therefore, not the exclusive use of any splint, but the use of such means as may meet the indications as they are present. During the acute stages, the hip-joint should be fixed efficiently in bed. This implies the use of thorough traction. Continued confinement to bed is not beneficial to the general condition of tuberculous patients, except temporarily during the acute stage; and as soon as the acute symptoms have subsided the patient should be allowed to go about with the hip thoroughly protected against jar and spasm. This can be done by means of a traction splint, if efficiently applied, with at first the additional protection from crutches.

If the acute symptoms return under this method, thorough rest in bed is again indicated in addition to efficient traction and fixation. If the acute symptoms diminish and there is less muscular rigidity at the hip-joint, greater freedom can again be allowed, and eventually traction discontinued, and the joint merely protected from jar. This should be continued so long as there is any danger of recurrence of active symptoms or tendency to contraction.

In brief, the hip should be fixed as long as it is sensitive, should be protected and distracted as long as there is muscular spasm, and protected as long as it is weak. The best results are attained only by thorough treatment for a year at least, and careful supervision and protection for two or three subsequent years. Distortions of the limb should always be corrected as they occur. In many cases some motion can be saved at the hip-joint if treatment is not discontinued too soon.

Abscesses can be treated on general surgical principles. Radical operative measures are needed only in exceptional cases if thorough conservative treatment can be secured. Out-of-door air, the best obtainable surroundings, with as much activity as the local conditions of the joint justify, stimulating the circulation by exercise, and improving the appetite and the metabolism, are the antidotes at present available to the tuberculous condition. These, if combined with such surgical treatment as will protect the affected bone from frequent traumatism, may be relied upon to effect a cure in the greater number of cases of hip disease.

CHAPTER IV.

TUBERCULOUS DISEASE OF THE KNEE.

Definition.—Pathology.—Clinical history.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment, (*a*) conservative, (*b*) operative (excision,—arthrectomy,—amputation).

DEFINITION.

The other names by which this affection is known are tumor albus, white swelling, scrofulous disease of the knee, chronic purulent or fungous synovitis of the knee, etc.

The knee-joint differs in anatomical structure from the hip, in that the joint surfaces forming the knee are nearly flat and the facets in the tibia shallow. Owing to this fact, the tibia is easily drawn backward and flexed by the hamstring muscles, the flexors of the leg being much stronger than the extensors; at the same time it is rotated outward, the combination constituting the common and troublesome deformity which is the characteristic one after severe tumor albus.

The course of the disease in the knee does not differ in general from that in the hip, but the measures necessary for preventing deformity in the two joints are somewhat different.

PATHOLOGY.

Tumor albus, as it is seen in children, begins oftenest, if not always, as an epiphyseal ostitis of the tuberculous type. Like other forms of tuberculous disease, it is oftenest limited to certain portions of the epiphysis, and either the femoral or tibial epiphysis may be attacked primarily. Cases are occasionally seen, however, in which the primary focus is in the patella or in the head of the fibula. In children it is not uncommon to see an acute, apparently traumatic effusion gradually absorbed, leaving an infiltrated and thickened synovial sac. In the greater number of cases, however, the bone symptoms clearly precede the effusion.

The pathological appearances of tuberculous joints have been so fully described in speaking of the pathology (Chapter I.) that it is not worth while to enter upon them here to any extent.

In the severer cases a destructive, fungous, or purulent synovitis

generally develops, which becomes the characteristic feature of the process. This may end in a complete destruction of the joint or in arrest and recovery by absorption and cicatrization.

CLINICAL HISTORY.

The affection begins, as a rule, insidiously, with stiffness and limp in gait. The disease may be limited for a long time, and be manifested by an enlargement of the condyles or head of the tibia, or it may extend and involve the whole joint; occasioning severe pain, swelling of the periarticular tissues, effusion into the joint, periarticular abscess, and distortion of the limb (*i.e.*, flexion and subluxation), and ending in a natural cure with fibrous or bony ankylosis and a distorted limb, which may be more or less serviceable, according to the distortion; or the affection may result in such extensive suppuration as to endanger life from septic or amyloid changes. Sometimes in cases of moderate severity an attack of severe pain supervenes, and an acute stage is reached, when the limb is flexed at the knee, hot and tender to the touch, and sensitive to any jar. Under proper treatment this stage gradually subsides, and there may be left impairment of motion. Enlargement of the bone, if it persists for any length of time, is characteristic of chronic epiphysitis of the knee.

FIG. 141.—Tumor Albus. Joint shows general tuberculous process, without visible connection with the primary focus; a cavity in head of tibia of three centimetres diameter, filled with cheesy material. *a*, Tuberculous focus in femur. (Nichols.)

In the milder cases, arrest of the disease may occur at any time with more or less complete restoration of the joint. In the severer cases suppuration may follow, with the establishment of sinuses. The destructive process may become so extensive that excision or amputation is required. In general, the affection is favorably affected by proper treatment.

In tumor albus the most noticeable symptoms are heat, swelling, tenderness, and joint distention; while in hip disease, the joint being less accessible, a different class of symptoms, restriction of motion, limp, and distortions of the limb, are more to be depended upon.

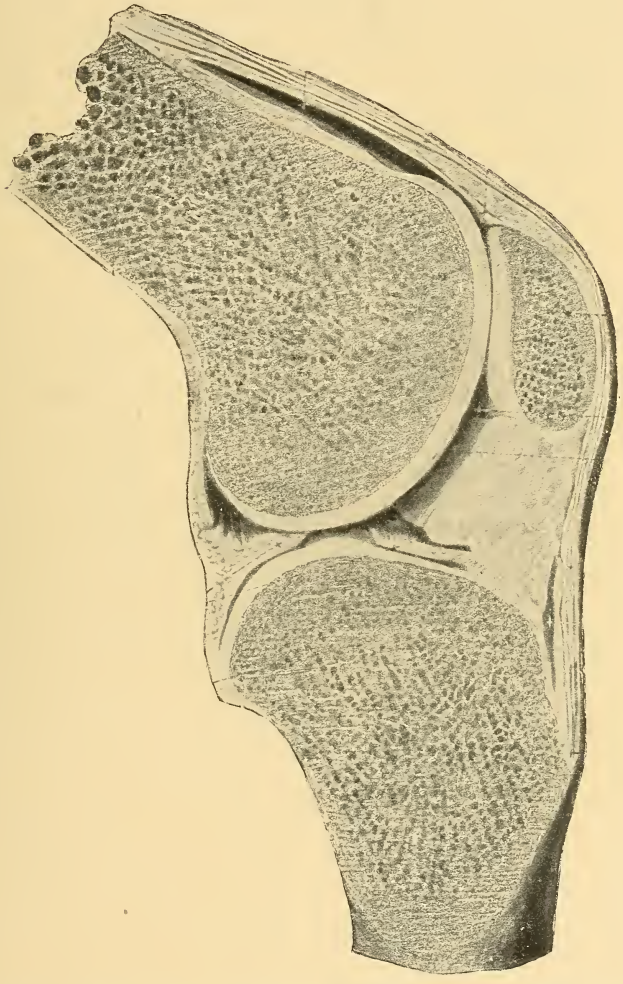


FIG. 142.—Right Knee-joint Bent. Sagittal section. Joint surface slightly separated, showing the infra-patellar fat pad, and the bursa under the patella tendon as well as the extent of the joint synovial membrane. (Fick.)

Swelling.—In tumor albus the knee will be seen to have lost its definite contour, the depressions on the sides of the patella have become filled out so that there is an indistinctness of outline which is as perceptible to the touch as to the sight. Most often the patella seems to be raised from its position by a semi-solid mass and the whole knee

seems surrounded by a boggy infiltration. Later it assumes a spindle shape and the distention causes the skin to be somewhat anæmic in the more severe cases, whence the name of tumor albus.

The swelling at the knee, unless suppurative synovitis is present to a marked degree, differs from that of synovitis with effusion, in that the swelling is of the bone and soft periarticular tissues, and is not altogether within the joint. If the effusion is large, as in chronic serous synovitis, the patella, when the muscles holding it are relaxed, can be depressed by pressing on it, and be felt to hit against the bone as it floats above the fluid within the joint. In effusion the shape of the swelling is characteristic. When effusion is the characteristic feature, it is most prominent on both sides of the patella, and is limited by the tendon of the quadriceps extensor muscle and by the ligamentum patellæ.

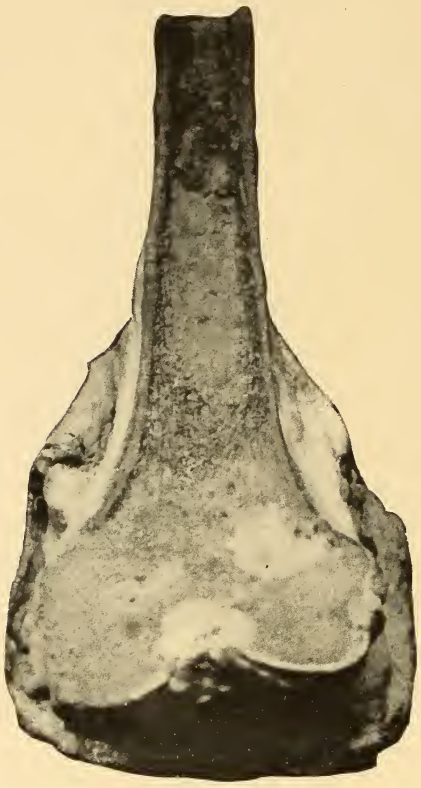


FIG. 143.—Tuberculous Knee in Adult. General synovial tuberculosis. Large irregular area of tuberculous softening in epiphyseal end of femur, extending into joint along crucial ligaments. (Nichols.)

In some instances, one of the condyles—usually the internal condyle—is enlarged more than the other, causing knock-knee.

Atrophy.—Atrophy of the muscles, both of the thigh and calf, is present, and reaches a serious degree inacute cases. It is more equally distributed between the muscles of the thigh and those of the leg than in hip disease.

Shortening.—Shortening is a much less important factor than in hip disease, and until late in the affection does not appear to any extent, and this late shortening comes as a result of the faster growth of the well leg oftener than as the out come of bone destruction. During the course of the disease *lengthening* of the affected leg may occur. The hyperæmia occasioned by the inflammation induces the overgrowth in all directions of the tibial and femoral epiphyses, so that they outstrip for a while those of the other leg. In measuring a child with tumor albus it is, therefore, not uncommon to find the diseased leg half an inch longer than the other. Later in the disease, the trophic disturbance

which occurs in all these tuberculous joint affections makes itself felt and the diseased leg falls behind the well one in its growth.

Pain.—The pain of the affection is, except during the acute exacerbations, not severe, though pain on jarring the limb is common. Night cries are much less common than in hip disease, but they occur. When, however, the patient does suffer from an acute exacerbation, the pain and tenderness are excessive. From the exposed condition of the

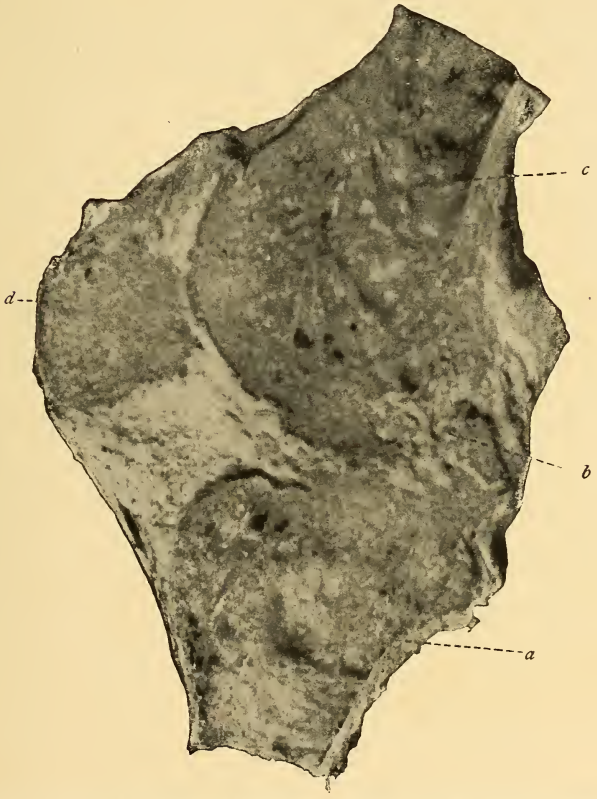


FIG. 144.—Tuberculous Knee, Process of Repair Advanced. Small focus persists. *a*, Tibia; *b*, tuberculous softening; *c*, femur; *d*, patella. (Nichols)

joint jars and twists are very common, and the suffering may be extreme. Tenderness is very common, especially over the inner surface of the head of the tibia. In certain cases, however, the knee is held rigid by muscular spasm, and any reasonable manipulation fails to occasion any pain.

Heat.—Heat of the affected joint is present and is a most valuable index of the progress of a case. It can be easily felt with the hand as long as the disease is active, but when it becomes quiescent it disappears, to return if anything goes wrong. It can be felt to diminish if treatment

is successful in quieting the condition of the joint, and is a most urgent indication for protective treatment so long as it exists in any degree.

Lameness.—Lameness is a constant symptom. It varies with the sensitiveness of the joint and is much influenced by the amount of flexion present in the diseased knee.

Muscular Fixation.—Muscular fixation is a symptom of this as of all chronic tuberculous ostitis, but is less prominent than in the hip. In the early stages it may be practically absent. The joint may be held perfectly rigid in full extension or in partial flexion, or a certain arc of motion may be permitted, and then the muscles quickly catch the joint and prevent it from going farther. Persistent muscular spasm results in the characteristic malpositions of the affection: flexion, and subluxation of the tibia.

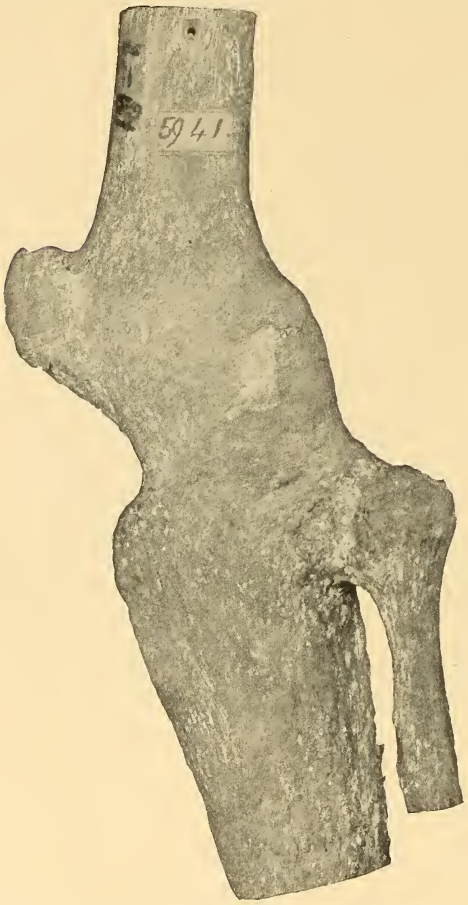


FIG. 145.—Bony Ankylosis of the Knee-joint, with Ankylosis of Patella.

Deformity.—*Malpositions of the limb* result from the greater power the flexor muscles of the thigh possess in contrast to the extensors. The limb becomes gradually flexed almost from the first, and if the affection goes on without treatment, flexion may reach a right angle, and this is the tendency of the disease throughout and a marked obstacle to its successful treatment.

Even when the affection is nearly cured or after a slight injury of the joint flexion may return, which is accompanied by increased heat and tenderness. Together with the flexion, and as a result also of the predominance of the flexor muscles of the thigh, subluxation of the tibia backward occurs at a later stage of the affection; this is due to the shape of the joint surfaces and the persistent contraction of the hamstring muscles always pulling the tibia backward. If the leg has assumed this distortion

and is straightened without an attempt to correct the subluxation, the tibia will lie in a plane back of that of the femur, and the part of the knee formed by the femur and patella will be unduly prominent.

FIG. 146.—Subluxation in Tumor Albus.

Another result of long-continued muscular spasm is the external rotation of the tibia upon the femur, which accompanies severe grades of flexion and persists after straightening of the leg if such is accom-

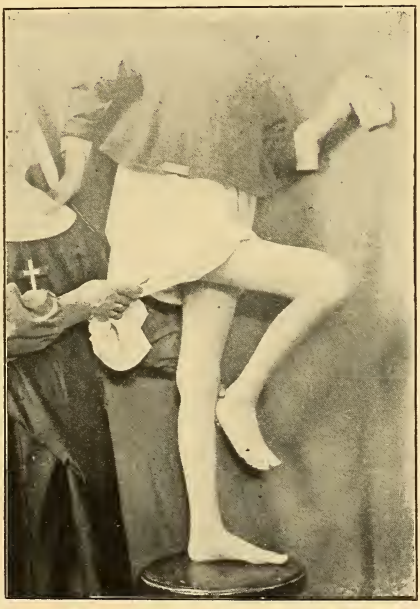


FIG. 147.—Position of Deformity in Tumor Albus.

plished. In the same way a certain amount of knock-knee is apt to be present in the corrected limb after severe grades of tumor albus.

Abscess.—Abscess appears either as a purulent distention of the cap-

sule, which may point at any part of the surface and discharge by sinuses for an indefinite time, or abscesses form in the periarticular tissues as in hip disease. As a rule abscess formation is accompanied by an acute degree of the affection.

DIAGNOSIS.

The diagnostic symptoms and signs in tumor albus are an intermittent lameness; a general enlargement of the knee-joint, with a feeling of stiffness and pain on using the limb; heat over the joint; and the presence of local tenderness and muscular stiffness in manipulation of the joint.

The character of the enlargement of the knee-joint is of great importance.

FIG. 148.—Tuberculosis of Right Knee-joint, with Marked Bony Enlargement at Inner Side of Knee.

DIFFERENTIAL DIAGNOSIS.

Gross errors in diagnosis in affections of the knee are not common, as a thorough examination of the joint is readily made. The distinction between a synovitis with effusion and a chronic ostitis is based on the size and shape of the swelling. The diagnosis is often aided by an *x*-ray examination. By the test of aspiration and guinea-pig inoculation, a diagnosis can be established.

Synovitis.—Sluggish cases of synovitis in young children should be regarded with very great suspicion, inasmuch as they are likely to eventuate in tumor albus at any time, if the condition is not already that.

Periarticular Disease.—Periarticular disease (inflammation of bursæ and periarticular abscesses) is to be distinguished from true articular disease in that there is little or no joint stiffness, and in that the swelling, if present, does not bear the relation to the patella that occurs when there is fluid beneath the patella; the distention being clearly outside of the joint sac.

Functional disease (hysterical, neuromimetic) of the knee is to be recognized by the absence of objective symptoms and the prominence

of subjective symptoms. Heat is generally absent, limitation of motion and tenderness may be excessive, and swelling and alteration of the joint contour are absent.

Arthritis Deformans.—A diagnosis between a tuberculous affection

FIG. 149.—Severe Tuberculosis of Knee-joint with Marked Swelling, Flexion, and Sinus.

and that form of arthritis deformans with synovial infiltration and change is difficult and can often be made only by a careful study of the case with the aid of the inoculation test. It is to be remembered

FIG. 150.—Tuberculosis of Knee-joint with Extreme Flexion Deformity.

that tuberculous disease is more common in childhood than is arthritis deformans.

Hæmophilia may cause an inflammation of the knee closely resembling tumor albus. The diagnosis must be made by establishing the existence of the bleeder's diathesis and by the course of the case.

PROGNOSIS.

The prognosis of tumor albus is similar to that of the same affections of the other large joints. The functional results after conservative treatment are in average cases excellent; sometimes perfect motion is restored, but in general only an incomplete arc remains with occasionally complete rigidity. The earlier that treatment is begun and the more faithfully it is carried out, the better is the outlook as to functional result. In advanced cases disability necessarily follows, and in neglected cases deformity of the limb, flexion at the knee, subluxation of the tibia, and the formation and discharge of abscesses are likely to occur, ending

FIG. 151.—Old Tumor Albus Recovered, Showing Degree of Possible Flexion.

either in a complete destruction of the joint or in a cure with ankylosis. A liability of the dissemination of the tuberculous disease to the brain or lungs exists in this as in other similar affections.

In all severe cases there is a danger of permanent distortion of the limb. This may be so severe as to render the limb useless. Flexion of the limb is a constant result in severe cases unless treated with great care. Shortening is less likely to exist to a troublesome extent than in hip disease.

As in all cases of epiphyseal ostitis of the larger joints, the prognosis as to the time of requisite treatment depends not only on the time needed to check the inflammation, but also for the re-establishment of sound bone tissue capable of bearing weight without danger of relapse. This in growing children demands a long time. Protection is generally

necessary for from one to two years, and perhaps even longer, after the acute stage is ended.

TREATMENT.

The treatment may be classed as conservative and operative.

Conservative Treatment of Tumor Albus.

What was said in regard to the treatment of hip disease may be

Fig. 152.—Old Tumor Albus Recovered with Motion, Showing Subluxation of Tibia.

repeated in speaking of epiphysitis of the knee-joint. The treatment should be thorough and persistent, and should meet the indications, and fixation and protection are the most important indications in diseases of the knee, while traction is less so. The employment of protection should be continued until it is probable that the epiphysis is normal, which is a matter of judgment in every case. Protection should be discontinued gradually and tentatively; if discontinued too soon, recurrence will take place, or the deformity of the limb will increase. Fixation should be used so long as there is any activity of the inflammation; this is

indicated by pain, muscular spasm, or tenderness. Efficient fixation of the knee does not require confinement to bed except in very acute cases, in abscess, and in deformity.

In cases in the acutest stage the patient is kept in bed with the limb held by weight and pulley traction and the foot and limb steadied by sand bags or side splints or by a splint plaster bandage. Ordinarily this acute stage is absent or is brief, and ambulatory treatment is both possible and desirable.

Fixation.—It is manifest that the most thorough fixation is made if the fixing appliance is as long and extends as high as possible. The leg and femur, if much longer than the appliance, will have a greater mechanical advantage than if the splints are sufficiently long. It should also be borne in mind that, owing to the fact that the thigh is well covered by soft tissues, a certain amount of motion is possible owing to the yielding of the soft parts. Fixation by stiff bandages is an efficient method of treatment when the bandages are properly applied. They should reach from the groin to the ankle, in the acute cases including the foot, and as firmly as possible grasp the muscles of the limb. Plaster of Paris is the most available material for use. The method does not give in all cases certain, definite support. Judson says in regard to it: "It may be an exaggeration, but it conveys the idea, to say that a plaster-of-Paris or silicate splint, applied to the leg and thigh, contains a mass of jelly in which the femur is but little restrained from motion." And in a degree this is true of all stiff bandages.

FIG. 153.—Tuberculosis of Knee-joint with Abscess.

The figure shows the inefficiency of a loosely applied plaster bandage so far as fixation is concerned. Other stiff bandages are of silicate of potash, leather, celluloid, wood pulp, papier maché, etc. They may be cut down the front and laced so as to be removed at any time. Fixation without protection is inadequate treatment when locomotion is

desired. For this reason it is insufficient to apply a stiff splint to the affected leg and to allow the patient to walk without further protection of the limb.

Fixation as a means of treatment so far has been considered only as applicable to the limb in its straight position. Much more often a

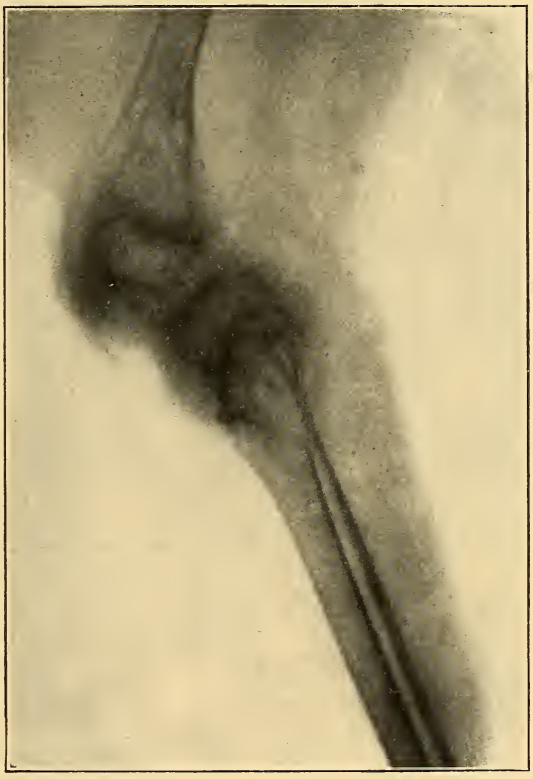


FIG. 154.—Radiograph of Old Tuberculosis of Knee-joint, Showing Destruction of Joint Surfaces and Bone, Flexion and Subluxation of Tibia.

degree of flexion is present to complicate matters, the treatment of which will be considered later.

Protection.—Protection can be furnished by means of crutches and raising the sound limb by a thick sole which allows the affected limb to swing clear of the ground. Better protection is furnished by means of a splint with perineal support and longer than the limb, which passes below the foot so as to take the jar of locomotion. The best of these splints is one similar to that already described as a protective splint in hip disease. It will be described more fully in speaking of the treatment of flexion in tumor albus.

Thomas Knee Splint.—A simple appliance is the Thomas knee splint

(Chapter XXI., **14**) which consists of a padded iron ring fitted so as to surround the thigh at the perineum, and fastened to two rods on each side of the limb, longer than the limb and secured at the bottom to a metal plate below the foot or bent to fit into a slot under the shank of the boot.

The bar at the bottom of the splint can be utilized as a means for using traction if adhesive plaster is applied to the leg and webbing sewn to the lower ends; the webbing straps are buckled tightly around the bar, and a certain amount of traction can be exerted. The idea of

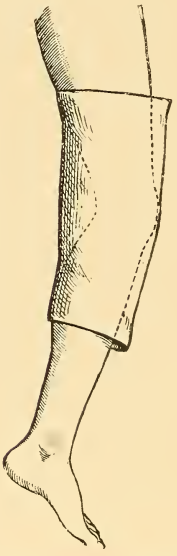


FIG. 155.—Imperfect Fixation of Knee-joint by Loose Plaster Bandage.

FIG. 156.—Imperfect Fixation of Knee-joint by Plaster Bandage of Improper Length.

using traction is not in accordance with the views of the inventor of the splint. The leg can be fixed by means of bandages and leather bands attached to the splint. With this splint applied, the patient sits in a ring supporting the perineum, while uprights run below the foot and bear the body weight.

In cases requiring less rigid protection and in the case of adults the inner half of the perineal ring is cut away and from the two extremities of the cut ring is slung a leather perineal band on which the patient rests in the same manner as in a hip splint.

In acute cases and cases tending to flexion the use of a plaster-of-Paris splint in addition to the Thomas splint is desirable, as better fixation is secured than by bandages. Traction is necessary only in very

acute cases; a stiff bandage to the knee in addition to the Thomas splint contributes better fixation than is possible with the splint alone.

The Thomas splint is slung from the shoulder by means of a strap, and the well limb is raised by means of a cork, wooden, or steel patten. Crutches are not necessary in connection with the Thomas splint.

Calliper Splint.—When the condition of the limb has improved so much that spasm and sensitiveness are absent or in mild cases the Thomas splint (Chapter XXI., **15**) can be shortened and the ends slotted into the sole of the shoe at such a place that the splint is too long for the heel to touch the ground, and in this way the patient walks about suspended largely by the perineal ring and bearing but little

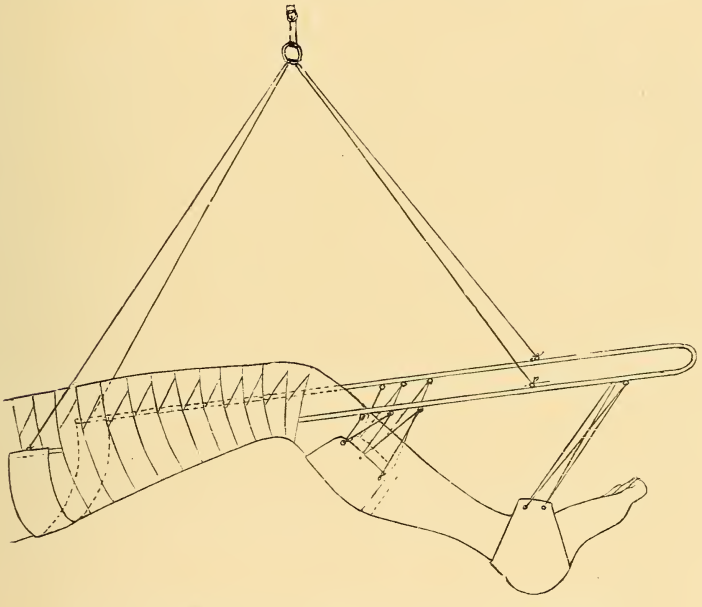


FIG. 157.—Wire Splint for Gradual Correction of Knee Flexion.

weight on the diseased joint. Then gradually after some months the use of the splint may be discontinued.

When convalescence has been further established and protected motion at the joint is possible, the knee splint may be jointed with a spring catch and check to limit the amount of motion.

Blisters, cauterization, and counter-irritation are beneficial only in relieving the symptoms of pain temporarily.

The treatment by passive hyperæmia and dry heat is useful if at all in the milder and more chronic cases.

Treatment of Complications.—*Deformity.*—Flexion of the knee is commonly seen even in the early stage of the affection, associated in the early part of the disease with an acutely sensitive condition of the

joint, but later in the history it may come on insidiously and without pain.

The means of straightening a knee-joint flexed by acute disease may be classified as follows:

1. By traction in the line of the deformity applied (*a*) in bed; (*b*) while the patient goes about.

2. By simple fixation by means of a succession of plaster-of-Paris bandages.

3. By straightening under ether.

1 (*a*). In sensitive cases it may be necessary to confine the patient to bed. Traction by weight and pulley can be applied to the leg by means of adhesive plaster applied below the knee, the leg being supported by a firm cushion under the knee arranged so that traction comes in the line of the deformity. After a diminution of the spasm, which follows very soon upon the application of traction, the limb can be made straight gradually and fixed in a straightened position, and ambulatory treatment can be begun.

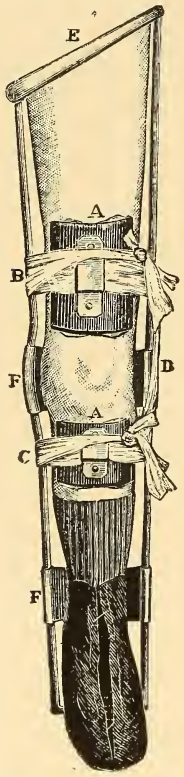


FIG. 158.—Thomas Caliper Splint, with Pads, Applied. (Ridlon and Jones)

1 (*b*). *Traction in the line of the deformity* can be applied to the limb while the patient goes about, by one of several appliances which are more or less expensive. The best splint is one already alluded to, similar to the protection splint described for hip disease (Chapter XXI., **16**).[1] It is furnished with a perineal band which takes the body weight off of the leg, and at the knee is a lock joint which can be set at any angle. The bottom of the splint goes far enough below the foot to protect the limb from jar in walking, and ends in a traction bar. The splint is set at an angle corresponding to the angular deformity of the affected knee, and traction is made upward above the knee by means of adhesive plaster attached to the thigh and buckling on to the splint, and extension is made downward below the knee by a plaster extension pulling down to the traction bar at the bottom of the splint. The leg is fixed in the splint by leather lacings for the thighs and calf, which are adjusted after the extension is tightened. A simpler apparatus has been described,[2] made of plaster of Paris and serving the same purpose except that it does not allow weight bearing on the affected leg.

[1] Lovett: Orth. Trans., vol. vi.

[2] H. L. Taylor: Orth. Trans., vol. vii., p. 53.

2. *Reduction of Flexion by Fixation Bandages.*—A very simple way to straighten a knee-joint acutely flexed by disease, when apparatus cannot be afforded or is impracticable, is by simple fixation of the knee-joint by means of a series of plaster-of-Paris bandages. These should be applied to the knee in its deformed position without any attempt to extend it. It will be often found in the lighter cases that the limb can be made straighter at each successive bandage, so great is the sedative action of complete fixation. It is hardly necessary to add that no weight should be borne upon the limb during the process of straightening.

3. *Forcible Reduction of Flexion.*—In cases without adhesions the knee is easily put in a correct position with the use of little or no force

FIG. 159.—Reduction of Flexion Deformity by Traction in Recumbency.

under complete anæsthesia. If the leg is allowed to remain in the flexed position, angular ankylosis will probably occur, as shown in the figures. When firm adhesions have been formed at the knee-joint, correction by means of appliances will be found tedious, painful, and sometimes impossible, and generally forcible correction of some sort will be necessary to break down the adhesions. One way is to break down the adhesions by forcibly flexing the leg, and then by forcible extension to straighten it. The danger of rupturing the popliteal artery, which has occurred, is in this way diminished. Many appliances have been devised to give greater power in forcible correction. One procedure not requiring the use of apparatus is as follows: The patient is placed upon the floor upon the back and the surgeon stands over the patient, holding the flexed knee with both hands, the fingers being placed

under the popliteal space. The whole weight of the surgeon's trunk can be thrown upon the end of the lever furnished by the patient's leg, the hands of the surgeon, pulling upon the popliteal space, furnishing resistance. After the limb has yielded and the adhesions are broken, it can be straightened if the patient is turned upon the face; a downward force being applied to the heel, resistance being furnished by a cushion placed under the patient's knee. When subluxation of the tibia is present it must be corrected. This cannot be done so well by this method as by the instrumental method to be described. After correction, the limb should be well surrounded with sheet wadding and a stiff bandage applied, the limb being held straight until the plaster has become hard. The procedure is sometimes followed by pain, and opiates may be necessary for a few days. Such measures are not required except in resistant cases. The dangers incurred by this pro-

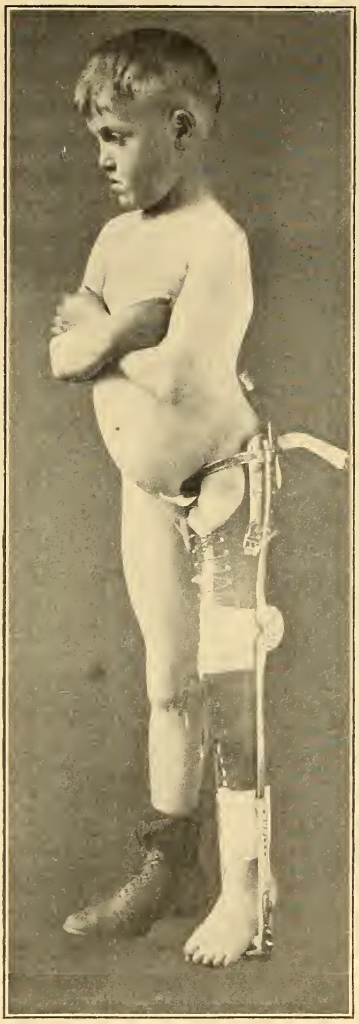


FIG. 160.—Jointed Traction Knee Splint Applied.

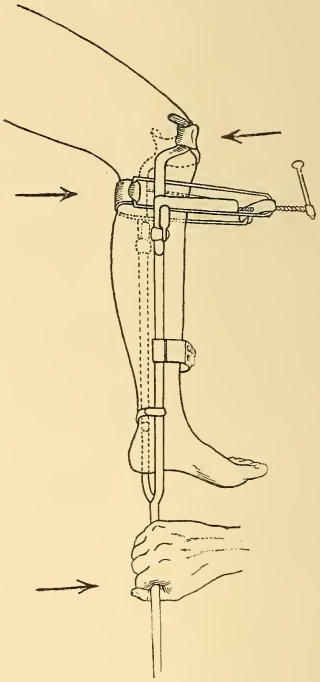


FIG. 161.—Goldthwait's Genuclast Applied.

cedure are not so great as would be supposed. The danger of rupture of the artery can be avoided by care. Separation of the epiphysis of the femur may take place, but is cured by the fixation requisite to treatment, and should not occur if the force is carefully applied. Fracture of the femur and tibia can be avoided by care.

If the deformity, flexion, remains uncorrected in severe ostitis of the knee-joint, a subluxation of the tibia backward takes place, due to the contraction of the hamstring muscles. This is due in part to the spasm of the hamstring muscles, which have pulled the tibia backward, but chiefly to the fact that owing to adhesions the flexed tibia is unable to slide forward over the condyles of the femur, as happens in normal extension. Attempts to straighten the leg simply crowd the anterior edge of the tibia into the condyles. To obviate this the head of the tibia should be pressed forward and upward to the same degree that the leg is raised.

The most efficient method of accomplishing this is by the use of the apparatus shown in the figure called by Goldthwait,[1] who modified it from the original apparatus, the "genuclast."

Pressure forward on the head of the tibia is exerted by turning the handle; this, by means of a screw force, pushes a plate forward against the tibia, working through a band. The calf muscles protect the artery and nerve from injurious pressure. Counter-pressure is secured by means of leather straps, which are passed respectively over the knee and leg, protected by a thick layer of saddler's felt. Several straps will be needed at the knee to prevent loss of counter-pressure, as the limb is made straighter. Another strap, under the leg, secures the lower part of the leg. The side bars, bands, and plate of the apparatus should be of strong steel.

The apparatus is put on the limb in a flexed position (after rupturing adhesions by forcible flexion if that is needed), the head of the tibia is pushed forward as far as is advisable, and, by means of the end of the appliance, which serves as a handle, the leg is extended; the pressure forward of the head of the tibia can be increased, and the counter-pressure regulated if necessary, by loosening such of the straps as extension of the limb may tighten too much. In some cases the reduction may be accomplished at one time, while in others successive applications of the apparatus are necessary. Adhesions of the patella to the front of the femur may constitute an obstacle to reduction without cutting. The treatment of cases resisting this method will be considered in the section of this chapter on operative treatment.

Experiments on the cadaver which were conducted by one of the writers at the Harvard Medical School, through the courtesy of Drs. C. B. Porter and T. Dwight, showed that by means of this appliance

[1] Boston Med. and Surg. Jour., September 7th, 1893.

the tibia could readily be pushed forward to any desired extent. On normal joints, the tibia can be pushed forward to a considerable distance without rupturing the ligaments.

In general, correction of flexion deformity under ether is the best method except in slight cases.

Abscess.—The treatment of abscess is the same that is recommended for the treatment of abscesses at the hip, except that they are generally more superficial and can be opened earlier. They do not dissect about between the muscles to the extent that hip abscesses often do.

Operative Treatment of Tumor Albus.

The operative measures to be considered are:

1. Excision.
2. Arthrectomy and erasion.
3. Amputation of the leg.

1. Excision of the knee-joint is to be undertaken in those cases in which conservative treatment has failed to arrest the progress of the disease; in which originally the disease is too extensive to warrant conservative treatment; in which the general health is failing and the disease failing to improve under efficient conservative measures. In adults it is to be undertaken earlier than in children, as the progress of the disease is in the former less favorable than in the latter.

Excision is inferior to conservatism as a treatment of knee-joint disease in children, because the functional results are not so good.

Excision of the knee is also performed to correct the deformity caused by bony ankylosis at an angle of flexion.

It would be fair to assert that in patients between five and twenty, the mortality from the operation, *near* and *remote*, would not be far from ten per cent, being less rather than more than this percentage.

The functional results after excision are, however, inferior to the results after conservative treatment. Ankylosis is to be hoped for after excision and is complicated by a tendency to flexion of the apparently ankylosed joint.

It may be said with regard to the amount of shortening after excision in cases in which the epiphyseal lines are saved that it is likely to be only moderate, although even then it is more than after conservative treatment.[1]

Operation.—The operation of excision of the knee-joint is performed as follows:

The leg should be carefully prepared for an aseptic operation. The use of the Esmarch bandage and tourniquet is advisable. The joint is opened by a free anterior incision passing from the inner to the outer

[1] Arch. f. klin. Chir., 1885, iv., 32.

side of the joint slightly below the patella, the ligamentum patellæ is divided, the periosteum and muscular attachments are cleared from the ends of the bones, the ligaments are cut, and the articular end of the femur protruded through the incision and as much as seems desirable sawed off. In the same way the tibia is cleared and protruded as a safeguard against injuring the popliteal vessels. The patella should be removed if it is diseased.

In children it is desirable to avoid removing bone below the line of the epiphysis—a precaution not necessary in adults. It is best at first to remove a very thin section, just enough to take all the articular surface of both bones, and then to remove another section if the disease is very extensive, or if only foci of disease are seen to scoop them out extensively with a sharp spoon.

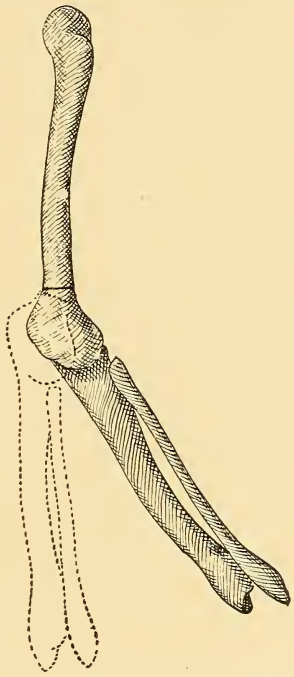


FIG. 162.—Osteotomy for Deformity with Ankylosis. (After Hoffa.)

It is of the utmost importance to attend carefully to the plane of section which the saw makes in removing the articular surfaces. If these planes are ever so slightly oblique, the whole axis of the limb is distorted and the line of weight-bearing is wrong and tends to cause angular deformity at the knee. In the femur the plane of section should be parallel to the articular surface and not perpendicular to the shaft of the bone, which would make it oblique at the joint. As soon as section of the bones has been made, the new surfaces should be placed in contact and the line of the limb carefully observed.

To secure fixation the bones may be wired together or fastened to each other by wire nails or pegs of ivory or bone. A wire posterior splint may be used, but, in general, a plaster-of-Paris bandage reinforced by a steel bar and with a window cut for dressing, the bandage including the foot, furnishes the best means of fixation, the bones having been fixed accurately in position by some of the means mentioned and the limb after that handled very carefully. The only objection to it is that in the profuse discharge of serum which takes place necessarily from so large a wound within the first twenty-four hours, the plaster is likely to be stained through and may have to be changed. But if a sufficiently heavy dressing is put on, this will ordinarily not happen to any extent, or if it does a light dressing can be applied outside to protect

the stained spot. Occasionally the plan is useful to dress the limb after operation in a heavy dressing and on the next day to redress it and apply the plaster. In this way one may be almost sure of a dressing which can be left on almost indefinitely, provided the operation has been aseptic.

There are two precautions to be observed in putting the leg up in splints or in plaster: first, the tendency to eversion; and second, the tendency to dropping backward of the head of the tibia. With moderate precautions these deformities may be avoided. When the bones are wired together, if the holes which are bored in the tibia for the insertion of the wire are placed well backward and the corresponding holes in the femur well forward, much will be done to counteract this backward displacement of the leg upon the thigh.

A protection splint is to be worn for some time to prevent the recurrence of flexion. It is much the wiser course to have the patient wear a perineal crutch (in the form of a Thomas knee-splint), which shall prevent bearing any weight on the leg until several months after operation. If this precaution is neglected, permanent flexion of the limb is likely to occur or a lighting up of the original disease.

Excision of the Knee for Angular Ankylosis.—When excision of the knee is done for angular ankylosis, the only modification of the operation which is necessary is the removal of a wedge of bone large enough to allow the ends of the bone to come together, so that the angularity is obliterated.

Osteotomy of the femur is a measure which may be used to correct flexion deformity at the knee too strong to be overcome by forcible straightening. The osteotomy should be linear and as near the joint epiphyseal line as possible. This can be employed in place of a wedge-shaped excision for angular deformity, as not involving shortening. The osteotomy is followed by careful straightening of the limb. The advantage of this method lies in the fact that any motion remaining at the joint is not destroyed as it must be in excision. Its disadvantage is that the condyles of the femur are necessarily displaced forward to form an angle with the shaft. A linear or wedge-shaped osteotomy of the upper part of the tibia has been described by König for the same purpose.

2. Arthrectomy.—As a substitute for excision, what has been termed arthrectomy or erasion has been employed.

Arthrectomy consists of the removal of all palpable and obvious portions of diseased tissue, whether in the synovial membrane or elsewhere, leaving what appears to be healthy tissue. Two advantages are claimed for this operation over excision: (1) That it does not interfere with the growth of the limb, and (2) that mobility of the joint may be preserved. It may be added that the latter is an exceptional event and

not altogether so desirable or safe an ending under the circumstances as bony ankylosis. The objection to the operation is that it is not thorough, and oftener than excision fails to eradicate the disease.

The operation offers advantage over excision only in the case of children and chiefly before the disease has made extensive progress. It is easy to see that, if any extensive disease of the bone is present, any measure short of thorough removal must necessarily fail. The operation is, therefore, not suited to cases in which there are many sinuses and bone enlargement, but to milder cases as a less severe operation than formal excision.

In the matter of risk there is little to choose between this operation and excision, for the immediate death rate under proper precautions is very small in both operations. The risk of operative tuberculous infection, alluded to so often in speaking of operations upon tuberculous joints, is present in arthrectomy as in excisions.

Operation.—The operation itself may be described as follows: The joint is opened as in cases of excision and the tuberculous synovial membrane as far as possible should be dissected out; if diseased spots are found in the bone or have been previously located by the *x*-ray, these foci should be removed by the curette or chisel, and the cavity left in the bone wiped out with pure carbolic acid and alcohol, and the joint sewed up or drained according to the extent of the disease and the general aspect of the case. If the whole epiphysis is diseased, excision is of course unavoidable. Instances of excellent recovery with complete healing occur after this operation, and success has followed the procedure in many cases in the practice of the writers. The most thorough removal possible of all tuberculous tissue in the affected joint is essential, necessitating sometimes complete dissection and removal of all of the synovial membrane, as well as careful curetting of the bone. The patella should be removed or left, according to its condition.

The parts of the knee-joint to be most carefully investigated for diseased foci are the synovial pockets and the epiphyseal lines of the femur and tibia at their lateral aspects. Here one may find foci of tuberculous material extending into the epiphysis, without, however, in most cases crossing the epiphyseal lines.

The after-treatment should be like that of excision, except that wiring or nailing the bones together is not necessary, as the ligaments should be preserved so far as possible.

Flexion of the limb may follow arthrectomy as well as excision[1] in cases in which protection to the joint has been discontinued too early, so that the after-treatment should be as careful and as prolonged as after excision of the joint.

3. Amputation.—In cases of extreme disease of the knee-joint

[1] Hofmeister: Abst. in Arch. f. Orth., i., 2.

amputation of the thigh is necessary as a life-saving measure. As for the indications determining a choice between excision and amputation, it can be said that when the patient's reparative power is slight an amputation is to be preferred. The question is largely one of individual judgment; if excision is first tried and fails to arrest the disease, and finally amputation has to be performed, the patient's chances are, of course, injured by the choice of excision in the first place. In the adult extensive removal of the bones may be accomplished by excision without any danger of arrest of growth, and few patients can be brought to consent to amputation of a limb so long as any other method of treatment holds out the faintest prospect of relief. In children amputation should be deferred to the last moment and excision given the preference, unless the eradication of the disease would necessitate the removal of so much bone that a useless leg would result from that.

In children, therefore, the operation could be advised only when the joint was hopelessly disorganized and so much of the shaft of the long bones was evidently diseased that an excision was not practicable.

Summary.

The treatment of tumor albus should consist in *fixation* of the diseased joint by plaster of Paris or some suitable splint, with traction in cases in which the muscular spasm is very marked. If ambulatory treatment is to be undertaken (which is almost invariably to be advised), *protection* is also necessary. This is furnished by the Thomas splint, a high shoe, and crutches, or by the use of a protection splint similar to the one used in hip disease, etc. Fixation can be discontinued at the close of the acute stage, but protection is advisable for a much longer time.

Excision is not in children an advisable method of treatment until mechanical measures have proved inefficient after a faithful trial, and the same is true of arthrectomy. The latter is not suitable for adults. Deformities should be corrected as they arise.

CHAPTER V.

TUBERCULOUS DISEASE OF THE ANKLE AND OTHER JOINTS.

ANKLE.

Ankle (Symptoms.—Diagnosis —Prognosis. — Treatment). — Shoulder (Symptoms.—Treatment).—Elbow (Symptoms.—Treatment).—Wrist (Symptoms.—Treatment). — Sacro-iliac disease (Etiology. — Symptoms. — Diagnosis. — Prognosis. — Treatment).

The seat of the disease may be in the articular end of the tibia or in the astragulus; and other adjacent bones may be involved secondarily or independently, as the os calcis, the scaphoid, cuboid, and cuneiform bones. The pathological process does not differ from that already described, but on account of the numerous synovial sacs in the tarsus and the proximity of the bones to each other, extension of the disease is favored.

Symptoms.—Pain and tenderness of the whole joint to pressure and motion may or may not be present. Tenderness, as a rule, is present over the joint capsule in front, and perhaps under the malleoli, and swelling and heat are invariable accompaniments of the affection. Muscular rigidity is marked in most cases.

Lameness is an early and a marked symptom. Sometimes it is produced by the pain which weight-bearing causes in walking, but more often by the muscular stiffness which will not allow the ankle-joint to bend. The swelling consists of a boggy infiltration of the soft parts around the ankle, along with a distention of the joint capsule by gelatinous granulations. In character it is œdematous. This swelling is uniform around the ankle, except when an abscess is pointing on one side. The depressions in the contour of the ankle in front and behind the malleoli disappear in the swelling. The foot in affections of the ankle-joint usually assumes a position with the toes pointing downward, and in chronic cases with the foot slightly rolled outward (in the position of equino-valgus). This, however, is not the only malposition, for the foot may assume the position of pure talipes calcaneus. These malpositions are brought about by the abnormal tonic muscular contraction, and these deformities yield of themselves and the foot returns to its normal position when the irritation is quieted in the joint by proper treatment.

Wasting of the thigh and calf muscles occurs. Abscesses may occur.

When the disease attacks the medio-tarsal or tarso-metatarsal joints, the anterior part of the instep appears swollen and is hot and tender.

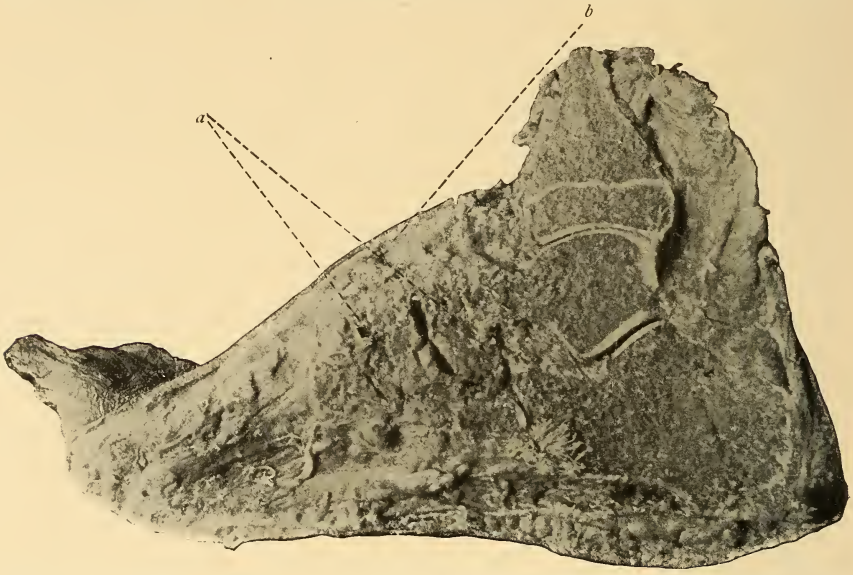


FIG. 163.—Tuberculous Ankle-joint. Diffuse tuberculosis of tarsus. Primary focus lost in the area of destruction. *a*, Tuberculous infiltration of soft parts; *b*, tuberculous softening of tarsal bones. (Nichols.)

Motion at the ankle is but little restricted, but motion in the anterior part of the foot is attended by pain and is usually lost. The location of the affection is evident from examination. If the os calcis is attacked

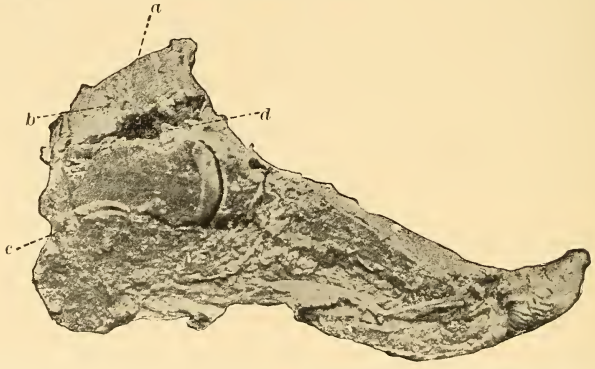


FIG. 164.—Tuberculous Ankle. *a*, Lower end of tibia; *b*, tuberculous cavity in tibia; *c*, tuberculous disease of calcis; *d*, tuberculous disease of astragalus. (Nichols.)

primarily it is manifested by the same symptoms of local inflammation without any symptoms referable to the ankle-joint.

The recognition of disease of the ankle is dependent on the symptoms given above.

Diagnosis.—The most troublesome affections to diagnosticate from ankle-joint disease are the *functional affections* which result often from sprains and injuries. Here it is not uncommon to find, in hypersensitive women chiefly, a limitation of motion of the ankle, with much pain on manipulation and pressure; there may be swelling left over from the injury, and the question to be decided is whether any disease of the joint exists which can well be made worse if the patient goes about, or if it is a disturbance of circulation and innervation which can be overcome by judicious management. In one case rest is indicated, in the other activity. The diagnosis of functional joint disease is considered in full in the proper place.

One must depend chiefly upon the existence of the objective signs of ankle disease, rather than upon the patient's feelings; allowing, however, due weight to the history of the affection and the patient's sex and constitution.

Inflammatory flat-foot may at times present symptoms similar to those of ankle-joint disease. Rest and measures to quiet the process will quickly control the symptoms in flat-foot but not in tuberculosis.

The *x*-ray is of value in establishing the diagnosis.

Prognosis.—Unless the disease is advanced, children who are in good condition as a rule make good progress under conservative treatment. The prognosis is somewhat better when parts other than the astragalo-tibial joint are affected. The prognosis in adults under conservative treatment is less favorable.

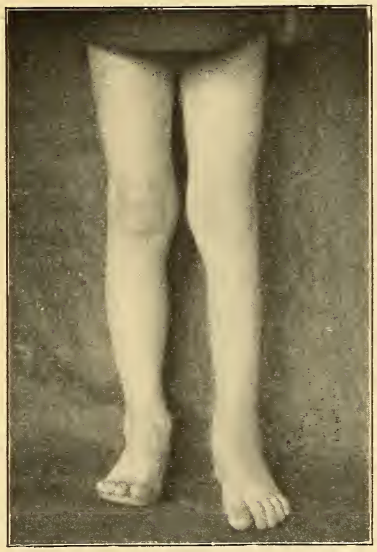


FIG. 165.—Ankle-joint Disease at an Early Stage.

Mechanical Treatment.—Protection from jar is indicated, as well as fixation of the joint—as will be readily seen if it be borne in mind that in locomotion the whole weight of the body is borne at each step upon the comparatively small surface of the upper articulating portion of the astragalus. Fixation of the ankle in a stiff bandage, while allowing the patient to walk upon the limb, is a manifest error, as affording little or no real protection to the joint. Fixation is of advantage in the more acute stages of the affection, and is readily furnished by means of stiff bandages. A plaster-of-Paris bandage is the most convenient appliance, and should be carried above the knee so as to fix that joint also. A fixation ankle brace (Chapter XXI., **17**) may be used instead of the

plaster-of-Paris bandage. Protection can be furnished either by means of crutches or, more thoroughly, by means of protective splints with perineal supports described for the knee-joint. The Thomas knee-splint is one form available (Chapter XXI., **14**).

Such apparatus for fixation and protection should be worn through the acute stage of the disease. If abscesses form they should be incised and traced to their source, and if loose bone is detected this should be removed. If the foot assumes a malposition, this should be corrected; this is best done by applying a plaster bandage to the foot in its malposition and quieting thereby the inflammation so much that

FIG. 166.—Tuberculous Ankle. Advanced Stage.

in two weeks the malposition will be found less and an improved position can be gained. Bier's congestive treatment is applicable in cases of tuberculosis of the ankle. The general health should be carefully inquired into and appropriately treated. All these procedures may be grouped together and be said to complete the expectant method of treatment.[1]

The conservative plan fully carried out is justifiable in a large proportion of cases, and on the whole the results obtained are good. In cases of tuberculous disease of the ankle where the progress is not satisfactory, the decision of continuance of conservative treatment or the adoption of operative interference is one which is based largely upon the patient's age and the circumstances of attendant care.

[1] N. Y. Med. Rec., August 21st, 1880, p. 197; Am. Jour. of Obstet., 1880, p. 434.

Operative Treatment.—There are three alternatives left if the expectant method fails. The mildest form of operative interference consists in curetting the sinuses and removing what diseased bone it is possible to reach. Occasionally it may be possible to scrape out a focus of tuberculous material in the os calcis, but in the tarsus proper it is rarely a satisfactory procedure. The second operation is a formal excision of the diseased bones. The third and most radical measure is amputation of the leg or foot.

The question arises, Will the disease in the foot cease if the bone is removed? It may be said that, if thoroughly removed in children, relapse is unlikely to occur. More relapses occur from partial operations and from gougings and scrapings than from any other cause. The earlier excision is done and the more thoroughly the diseased bone is removed from the tarsus, the better is the result.

The operation should be performed by the subperiosteal method; the diseased tissue should be removed from the end of the tibia and the astragalus removed entire with the top of the os calcis, if diseased.

There are many modifications of the lateral incisions which are in common use and other incisions radically differing; but of all methods preference must be given, in the opinion of the writers, to that of Kocher, which has proved eminently satisfactory in their experience when a formal excision is to be done.

FIG. 167.—Treatment of Ankle-joint Disease by Thomas. Knee splint and plaster-of-Paris bandage on ankle.

The method is as follows: The foot is held at a right angle and a superficial incision is made along the outer border just below the external malleolus, reaching from the tendo Achillis to the extensor tendons. The peroneal tendons are dissected out, secured by sutures, and then cut by a second and deeper incision. The capsule along the anterior and posterior surfaces of the tibia is cut, the external lateral ligament divided, and the ankle-joint thus opened freely from the side. The foot is then dislocated inward as far as is desired, and the joint can be inspected to any extent. After the diseased parts have been removed, the foot is reduced to its proper position, the peroneal tendons are united, and the wound is closed. When the

foot is dislocated, an admirable view is obtained of the interior of the joint.

The after-treatment of cases of ankle-joint excision is similar to the treatment of the others spoken of. Asepsis and immobilization in a correct position are the requirements; and to this end infrequent dressings are very desirable. Plaster of Paris applied outside of a heavy dressing is very serviceable, as in knee-joint excision. An accurate and equally efficient splint is a wire posterior splint, which is made of a rod of "copper-washed iron wire" three-sixteenths of an inch in diameter, which is bent to fit the leg and padded except at the ankle, where it is covered with rubber tubing and can be rendered aseptic and incorporated in the dressing there. The rest of the splint is padded. What-

FIG. 168.—Radiograph of Ankle Ten Years after Cure following Removal of Astragalus for Disease. (Case of Dr. A. T. Cabot.)

ever splint is used, one must be careful to see that the foot is at a right angle to the leg and in the same plane. For a long time after excision the joint should be protected from weight-bearing by the application of a Thomas splint or some such appliance.

SHOULDER.

Symptoms.—The general symptoms of ostitis of the shoulder differ in no way from those in the usual form of this disease in other more commonly affected joints, except that stiffness of the joint and malpositions due to muscular spasm are less noticeable on account of mobility of the scapula. The disease is insidious, extremely chronic, prone to suppuration, and decided impairment of the joint is likely to result.

Pain is of a dull aching character, which is usually aggravated at

night, and is referred either to the joint itself or to the middle of the arm near the insertion of the deltoid. In many cases this symptom is absent or very slight. A slight increase of surface temperature may be detected. There will usually be found a tenderness, frequently localized over a small area, generally over the anterior surface of the joint, but sometimes on its posterior aspect. The patient instinctively holds the arm at rest, and attempts at passive motion provoke muscular spasm, and if the attempt is persisted in, the humerus and scapula are seen to move together. Early in the disease a change in contour of

FIG. 169.—Disease of Right Shoulder-joint Showing Atrophy and Change in Outline.

the joint becomes apparent, which is due to enlargement of the head of the humerus as well as to muscular atrophy. When the swelling is due to effusion within the joint, the shoulder appears fuller and broader than normal, and this is seen best in looking down on the patient; the natural depressions in front of and behind the joint become either obliterated or are the sites of prominences.

Suppuration may occur. The subsequent course is slow, the result depending on the extent of the degenerative process, which may terminate soon after evacuation of the pus or continue to complete destruction of the head of the humerus.

The possible results are: recovery with a stiff joint (ankylosis), deformity and impaired muscular power, or entire destruction of the

head of the bone; and in children later arrest of development of the humerus may result.

Treatment.—In tuberculous ostitis at the shoulder-joint the indications for treatment are practically the same as those presented in other joints. Distraction is not indicated in disease of the shoulder, as, owing to the laxity of the joint, the weight of the dependent arm, if kept at rest, is sufficient to separate the humerus from the opposing bone surface of the scapular articulation. In very painful cases, should traction be required, it may be applied by weight and pulley traction during recumbency.

On the whole, the results of the conservative treatment of tuberculous shoulder-joint disease are satisfactory except in the case of persons

FIG. 170.—Same Case as Fig. 169. Showing limitation of abduction in attempt to raise both elbows.

whose general condition is decidedly bad. The great freedom of movement of the scapula allows many arm motions to take place without any movement of the head of the humerus in the glenoid cavity, so that it is easy to secure almost complete rest to the affected joint.

Excision of the joint should be performed if conservative treatment fails, being done earlier in adults than in children.

The longitudinal anterior incision is in general the most useful for excision of the shoulder. The periosteum is divided with a bone knife, inserted along the inner border of the bicipital groove. The arm is rotated both outward and inward, and the periosteum and muscular attachments are removed as they appear. The head can be removed with the keyhole or the chain saw, removing as much of the bone as is

diseased. The operation is performed subperiosteally and the head of the bone may be thrown out of the wound and thus sawed off. In after-treatment very good fixation can be obtained by bandaging the arm to the side, with a thick pad between the body and the inner side of the arm. Plaster-of-Paris dressing around the arm and chest affords the

FIG. 171.—Radiograph of Tuberculous Disease of Left Shoulder. (Dr. C. F. Painter.)

best fixation; and after the need of complete fixation is passed, a sling answers every purpose.

ELBOW.

Symptoms.—The disease may begin with pain, but this is not severe and often is entirely absent. Limitation of extension of the forearm is a constant and early symptom, motion in this direction being distinctly restricted when flexion, pronation, and supination are free. A slight

increase of surface temperature is usually found, but its absence does not exclude the disease. Careful examination will reveal a slight amount of swelling even at this stage of the affection, shown by fulness and thickening on either side of the tendon of the triceps, and, looking at the elbow from behind, the joint appears broader than normal. As in other joints, wasting of muscles occurs rapidly. As the disease progresses the stiffness increases, motion in other directions is restricted and resisted by muscular spasm, and the joint is generally held at an obtuse angle. Starting pains may be added to the other symptoms, and become the source of great discomfort. The whole joint becomes involved in the swelling, the enlargement assuming a fusiform shape.

The swelling sometimes becomes very great. The skin may become riddled with sinuses, the tuberculous infection attacks the soft parts, and the whole elbow becomes a pulpy, granulating mass. This occurs in neglected cases of elbow disease and also as the result of relapses after excision of the joint. Tuberculosis of the head of the radius may exist, in which case limitation of rotation and local swelling are predominant symptoms.

The prognosis in tuberculous disease of the elbow is not favorable for re-establishment of motion, unless the affection is treated at a very early stage. The joint is so complicated that the disease involves a large and comparatively widespread surface of synovial membrane before its presence is discovered.

Treatment.—In tuberculous disease of the elbow fixation is demanded. This is best furnished by plaster of Paris or moulded leather, which can be worn for some weeks and then be replaced with little disturbance of the joint. The frequent readjustment of splints is objectionable in a sensitive joint. In any event, a sling is to be carefully worn, which shall support the hand and wrist as well as the arm, and whatever apparatus is used it is essential to remember that the elbow should be flexed to a right angle, for if ankylosis occurs in any other position a useful arm is not obtained.

When the joint is fixed by muscular spasm at an angle greater than a right angle, it will often be found possible to rectify this by the application of a fixation bandage to the arm in its malposition. This so quiets the muscular irritation that in two or three weeks it may easily be bent up a little and by the application of a succession of bandages it may often be brought into a right-angled position without the use of the least force.

If the disease progresses, it is of little use to continue conservative treatment; but one must proceed to arthrectomy, or, better yet, excision, before amputation becomes the only measure holding out any prospect of relief. Forcible manipulation of an ankylosed arm is sometimes useful after the disease has ceased to be active.

Excision of the elbow is perhaps indicated earlier in the course of the disease than is the case in any other of the larger joints. After infancy is passed, operative interference is indicated whenever it is clear that under expectant treatment the disease is growing worse. Under these conditions the results are not, as a rule, altogether satisfactory, but if the disease is allowed to go on, the elbow-joint becomes so disorganized that amputation becomes necessary.

Excision is also indicated for ankylosis in faulty position, as when the elbow is fixed in a position of much more than a right angle or very sharply flexed. The longitudinal incision is the most serviceable. The forearm is slightly flexed, and the incision, about three and one-half inches long, is made a little to the inner side of the median line over the triceps and ulna and is carried down to the bone throughout its entire length. The inner edge of the divided periosteum is raised from the ulna with the corresponding half of the tendon of the triceps, and the dissection is continued with the knife close to the bone, toward the internal condyle. Much care must be taken to preserve the connection between the periosteum, the muscular attachments, and the internal lateral ligaments. A similar dissection should then be made upon the outer side with the same precautions. The humerus is dislocated backward through the wound and sawed off wherever it may be necessary. In other cases it may be advisable to use the keyhole or chain saw, and so far as may be necessary the ulna is cleared and sawed through, the head of the radius being removed with the saw or bone forceps.

In certain cases, in which sinuses exist, it may be better to adopt some informal method of operation, which will be suggested by the location of foci by the *x*-ray or by the direction and location of the sinuses or abscesses.

The after-treatment is similar to that of other excisions: complete rest to the joint and fixation in a right-angled position. This at first can be best obtained by the use of a plaster-of-Paris splint applied outside of a large antiseptic dressing. Later, in the course of the convalescence, bracketed tin or wooden splints may be of use; or, if one desires, the original plaster-of-Paris splint may be bracketed with strips of iron.

In excision for elbow disease, as a rule, ankylosis is aimed at as the best possible result, so that passive motion is not to be considered; if, however, the operation is performed in adults for ankylosis or injury and the ligaments have been in a measure fairly preserved during the operation, it may be advisable to begin passive motion after a moderate degree of firmness in the tissues has been reached, as there is but little danger of a flail joint and it is reasonable to expect that a certain degree of motion at the joint may thus be obtained.

WRIST.

Symptoms.—Tuberculous disease is characterized by swelling, heat, and stiffness. If the disease is advanced, deformity and swelling will be added to the other signs. The hand may be held flexed on the forearm at an angle of 120° to 130°, and this position is fairly constant. Swelling appears first in the depressions between the tendons. Later, measurement will show the joint to have increased in circumference, and there is a fulness of outline, especially on the dorsal surface, and in destructive disease the swelling extends up on the forearm and down on the hand. Suppuration is very liable to occur, and the course of the disease is usually long and slow.

In the matter of diagnosis, it may be added that swelling is always present, and that with the wasting of the muscles, the heat, and the limitation of motion, it makes up the clinical picture of the disease.

Treatment.—In tuberculous disease of the wrist-joint fixation is indicated, and it is most easily obtained by the application of anterior and posterior common wooden splints and carrying the arm in a sling. Plaster of Paris or a moulded leather splint forms a more permanent dressing and is equally comfortable.

Compression is a valuable addition to the treatment, and Bier's congestive method,[1] as in the elbow and ankle, may be of use in addition to the usual mechanical measures.

Excision of the joint is indicated in cases in children which do not make favorable progress under conservative treatment, in the cases of adults with severe disease, and is to be undertaken earlier in adults than in children. The best result is either ankylosis or limited motion, and, therefore, as much bone as possible should be saved. Other things being equal, a loose joint entails less power in the hands and fingers than a stiff one.

The method of Lister is performed by a radial and dorsal incision. The radial incision commences at the middle of the dorsal aspect of the radius at the level of the styloid processes. It is directed toward the inner side of the metacarpo-phalangeal articulation of the thumb, and on reaching the radial border of the second metacarpal bone it is carried downward longitudinally for half the length of the bone. The soft parts are detached from the bones with the periosteal elevator or the blade of the knife, and the radial artery is thrust somewhat outward. The soft parts on the ulnar side are dissected up as far as is practicable, while the extensor tendons are relaxed by bending back the hand. The knife is then entered on the inner side of the arm for the ulnar incision two inches above the end of the ulna, and is carried downward in a straight line as far as the middle of the fifth metacarpal bone at its

[1] Freiberg: Amer. Jour. of Orth. Surgery, vol. ii., No. 1, p. 50.

palmar aspect. The tendon of the extensor carpi ulnaris is cut at its insertion into the fifth metacarpal and dissected up from its groove in the ulna, while the tendons of the extensors of the fingers with the radius are left undisturbed. The anterior surface of the ulna is cleared by cutting close to the bone. The anterior ligament of the wrist-joint is divided and the junction between the carpus and the metacarpus is cut, the former being extracted through the ulnar incision by bone forceps and the use of the knife.

If the hand is everted, the articular heads of the radius and ulna will protrude at the ulnar incision, and as much as may be necessary is then removed. The metacarpal bones are also protruded and dealt with in the same way. The articular surface of the pisiform bone is cut off and the trapezium is dissected out. The operation may, however, be performed by a long, single dorsal incision, a method identified with the name of Langenbeck, which should begin at the centre of the ulnar border of the metacarpal bone and the index finger, and be carried upward to the middle of the dorsal surface of the epiphysis of the radius, and dissected down to the bone. The sheaths of the tendons are lifted with the periosteum and carried to the radial side of the long incision; the hand is flexed and the articular surface of the upper row of carpal bones is exposed. The ends of the radius and ulna may be denuded and thrust through the wound and sawed off in the usual way. Here, as in other excisions, informal methods of operating may be necessary on account of the situation of abscesses and sinuses.

The operation is indicated when expectant treatment has failed, but the joint is so easily fixed and so accessible that mechanical treatment works at good advantage. Operation is attended with so much deformity of the wrist and such doubtful results on account of the very extensive surface of the serous membrane that excision should not be lightly undertaken. The after-treatment is simple, because the hand can be kept so easily at rest upon a palmar splint; but any form of splint may be applied which will afford permanent and efficient fixation. In children excision should be done only in severe cases, when conservative treatment has failed. As in ankle-joint excision, the whole of every diseased carpal bone should be removed.

SACRO-ILIAC DISEASE.

By sacro-iliac disease is meant disease of the sacro-iliac synchondrosis. This affection is also known as sacro-coxitis (Hueter), sacrarthrocace, and sacro-coxalgie.

Disease of this joint is a rare condition. It is essentially a disease of young adult life, being slightly more common in men than in women.[1] It occurs occasionally in children. Chronic sacro-iliac disease is generally tuberculous.

[1] Van Hook: Ann. of Surgery, 1888–89.

Etiology.—The etiology is also, in large part, similar to that of chronic disease of this type in other joints; traumatism and the strain of parturition being assigned as the commonest causes.[1]

Symptoms.—In the early part of the disease such symptoms as a slight abdominal distress, difficulty in micturition or in evacuation of the bowels, fatigue, a feeling of indisposition, etc., are often present and as the disease progresses more pronounced signs appear. Pain is nearly always present, and may vary much in intensity. It is made worse by standing and is almost always relieved by lying down. It is also apt to be more severe at night, and is increased by pressure upon the trochanters or wings of the ilia. The pain varies in situation, and

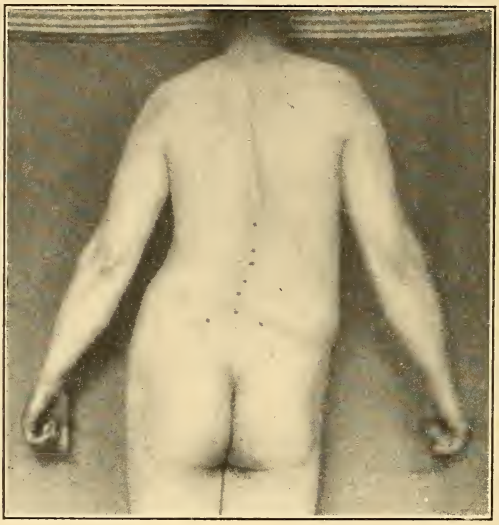


FIG. 172.—Sacro-iliac Disease (Non-tuberculous). (Dr. J. E. Goldthwait.)

may be referred to the course of the sciatic nerve. Sensitiveness upon pressure over the joint is a common symptom, and this may be developed over the anterior part of the joint by palpation through the rectum. Some swelling, or a boggy feeling, is usually present about the articulation, and if it goes on to abscess formation the fluctuating swelling may present at almost any point, either directly backward into the lumbar region, or it may become intrapelvic, in which case it may appear in the groin as a psoas abscess, or point in the ischio-rectal fossa, or at either of the sacro-sciatic notches. Limping is practically always present.

The position of the body in walking or standing is fairly characteristic, the weight of the trunk being thrown upon the well foot, while the other leg hangs down; this exerts a slight extension by its weight. In

[1] "Ref. Handbook of the Med. Sciences," vol. vi., p. 240.

walking the gait is very cautious, all jar is avoided, and hence the toe is largely used instead of the flat of the foot on the diseased side. Atrophy of the muscles of the leg upon the affected side is usually present, and is seen, as in other chronic joint affections, quite early in the disease.

Diagnosis.—Sacro-iliac disease has been mistaken for sciatica, but aside from the fact that the latter is usually found later in life, the pains are not relieved by the recumbent position.

In lumbago the pain is more diffuse and higher up than in disease of the sacro-iliac articulation.

Inflammation of the psoas muscle (psoitis) more usually simulates hip disease, but it may be mistaken for sacro-iliac disease. In this there is no tenderness over the joint and the pain which is present is increased by extension of the thigh, while flexion relieves it.

Positive diagnosis of sacro-iliac disease from hip disease and Pott's disease in the lumbo-sacral region is at times difficult and often impossible, especially in the class of cases just referred to. In hip disease all manipulation is resisted by muscular spasm, while in sacro-iliac disease, with the iliac bones held firmly, all motions at the hip are possible without pain. Also in hip disease the pain is never increased by pressure upon the wings of the ilia as is the case in sacro-iliac inflammation. In Pott's disease we have a prominence of some of the spinous processes with rigidity of the spine when motion is attempted, and local tenderness is not present over the sacro-iliac articulation, nor does pressing together the ilia cause pain.

Prognosis.—The prognosis in this disease is at best quite grave. Patients do recover, but it is one of the most chronic of joint affections, and usually goes on to abscess formation, with prolonged suppuration and death either from exhaustion, or renal complications, or secondary tuberculosis.

Treatment.—The principles of treatment are the same as in all chronic joint affections. In the acute stage the patient should be kept upon the back in bed, with weight-and-pulley extension to the leg to steady the limb, and as the acute symptoms abate he may be allowed to go about on crutches, with a high sole upon the well foot, the weight of the other leg serving as extension. While moving about, a certain amount of comfort may be derived from a swathe, of either leather, or adhesive plaster, or plaster of Paris, about the pelvis, which serves in part to fix the joint.

When an abscess has formed it should at once be laid open, any diseased bone removed, and treated like any cold abscess. When the abscess is intrapelvic it may be quite difficult to reach. Excision of the sacro-iliac synchondrosis may be done in severe cases.

In all of these cases tonics and constitutional treatment are not to be neglected.

CHAPTER VI.

INFECTIOUS OSTEOMYELITIS — INFECTIOUS SYNOVITIS AND ARTHRITIS.

Infectious osteomyelitis (Etiology.— Pathology.— Symptoms.— Diagnosis.— Differential diagnosis.—Prognosis.—Treatment).—Spine.—Typhoid spine.—Hip.—Acute arthritis of infants.—Infectious synovitis and arthritis (Etiology.—Pathology.—Treatment).— Gonorrhœal arthritis (Varieties.— Pathology.— Etiology.—Treatment).

INFECTIOUS OSTEOMYELITIS.

This process,[1] primarily attacking the bones and at times secondarily affecting the joints, is the result of an infection by some pyogenic bacterium. It attacks preferably the diaphysis of the long bones, generally near the epiphysis, and as a rule one bone only is attacked, but in exceptional cases several may be involved. It occurs usually in bone which has not become fully developed. If it is confined to the shaft of the bone the joints are not involved, but when it is located near the ends of the bone the joints are frequently invaded.

Etiology.—The organism most frequently found is the staphylococcus pyogenes aureus,[2] although the aureus and the citreus are sometimes present. The lesions produced by this organism are, as a rule, the most typical and extensive. The streptococcus pyogenes [3] is less commonly seen and the lesions caused by it are more liable to attack the periosteum and the superficial part of the bone, to cause separation of the epiphysis, and to involve the joints. The pneumococcus at times is the cause of a process indistinguishable from that caused by the streptococcus.[4] The typhoid [5] bacteria may cause suppuration in bone, usually in small and superficial areas, unless a secondary infection with some other organism is present. Secondary infections with other organisms have been reported. The femur, the tibia, and the humerus are the bones most commonly attacked.

Infectious osteomyelitis is not a specific disease, but the result of infection by one of a variety of pathogenic organisms, and it has been

[1] E. H. Nichols: Journal Am. Med. Assn., 1904.

[2] Lannelongue: Revue de Chir., 1895.—Lannelongue and Achard: Arch. de Méd. exp. et d'Anat. path., 1892.

[3] Lexer: Volkmann's kl. Vort., N. F., 173, p. 659.

[4] Fischer and Levy: Deut. Zeit. f. Chir., 1893.

[5] Keen: "Surg. Compl. of Typhoid Fever," 1898.

produced experimentally.[1] As a rule it occurs at or shortly after the age of puberty, although young children are often infected and adults are not exempt; it occurs more frequently in boys than in girls. The affection may arise in the bone without evidence of disease in other tissues, the organism finding its entrance through an unknown or apparently insignificant source of infection. The disease appears frequently after trauma, extreme fatigue, and exposure to cold and wet; it also occurs secondarily to a previous disease, such as typhoid fever, scarlet fever, or similar infectious disease. At other times it is secondary to a local infection in some other part of the body, such as furuncle, carbuncle, erysipelas, septicæmia, pleurisy, pneumonia, or empyema.

FIG. 173.—Acute Infectious Osteomyelitis of Tibia Involving Knee-joint.

Pathology.—The bone marrow is the part primarily attacked. The trabeculæ and cortex are at first but slightly involved, though later extensive destruction may take place. The process may spread extensively in the marrow before it pierces the cortex, where it extends and causes suppuration between the bone and periosteum and later in the soft tissues, developing an abscess which may evacuate, with the establishment of a sinus leading to necrosed bone. If the periosteum has been extensively separated from the cortex, extensive necrosis of the shaft follows, surrounded by a formation of dense cicatricial bone. As a rule the process does not extend to the epiphysis, but there may be a complete destruction of the epiphyseal line and a separation of the epiphysis. When ossification has obliterated the epiphyseal line the process may extend to the joint, being checked temporarily by the cartilage, but subsequently invading the joint, with joint destruction. Deformities develop as a result, but even when joint destruction has not taken place deformity may result from the destructive changes in the soft parts adjacent to the joint, which cause impairment of motion, ankylosis, and displacement of joint surfaces. When contiguous por-

[1] Lexer: Deutsch. med. Woch., xvi., 1894.—Ackerman: Arch. de Méd. exp. et d'Anat. path., 1895.

tions of bone are destroyed by necrosis extensive deformity may result.

Symptoms.—The affection begins suddenly with severe general disturbances, accompanied by pain in the affected bone, often in the vicinity of a joint which is held rigid on account of the pain. The attack may be of great severity and the symptoms may resemble those of typhoid, thus masking the local symptoms. At other times the attack is much less severe, the general symptoms being those of a moderate general infection. As a rule the local symptoms are of moderate severity, and in addition to the pain there are present swelling and tenderness of the parts about the affected bone, elevation of temperature of a greater or less degree, increase of pulse, and symptoms of sepsis in a degree varying with the severity of the case. Increased leucocytosis is

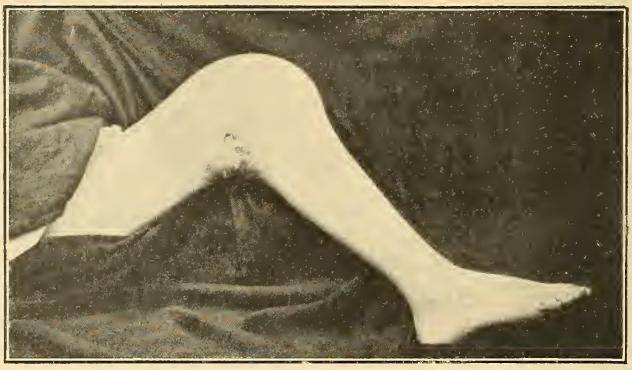


FIG. 174.—Acute Osteomyelitis of the Knee-joint.

present and delirium in the severer cases. This stage of onset, especially when of moderate severity, may be overlooked by the attendants of the patient, whose attention is centred on the severity of the local symptoms. If the disease is left unrelieved the condition becomes rapidly worse, in the severer cases markedly septic symptoms appearing.

Diagnosis.—The diagnostic signs of the condition are rapid onset, marked rise of temperature, mild or severe symptoms of sepsis, increased leucocytosis, and signs of a severe inflammatory process over the end of one of the long bones. In the early stage the *x*-ray does not afford a means of diagnosis.

Differential Diagnosis.—*Typhoid Fever.*—The initial stage of a severe type of the affection may be confounded with typhoid fever. In the latter, however, the bone symptoms when they occur are late and of less severity, and on careful examination cases of osteomyelitis will be found to lack the characteristic diagnostic signs of typhoid, the resemblance being only superficial.

Rheumatism.—The less severe grades of the affection are frequently

diagnosticated as rheumatism. The rapid development of osteomyelitis, the septic character of the symptoms, the severe localized pain, and the development of a process evidently suppurative will in most cases suffice to differentiate the two.

Tuberculous Disease.—In the mild cases the resemblance to an acute degree of tuberculosis of the joint is not infrequent. The process is, however, more acute and severe, the temperature is higher, leucocytosis is more constantly present, and although in certain cases the diagnosis is one of difficulty, it can ordinarily be made by a careful examination on the lines indicated in speaking of the two affections.

Prognosis.—In the severer types of this affection the condition is grave and the danger of septicæmia is considerable. The prognosis depends in a measure on the stage of the infection at which operative relief is afforded. In the less severe cases a stage of extreme pain persisting for some weeks is followed by abscess development with necrosis and the establishment of sinuses. When the affection is near the joint in young children the liability to dislocation and separation of the epiphysis is to be borne in mind. Young infants, who are frequently affected, in the majority of cases make good recoveries with early operative treatment. The motion of the joint is not necessarily lost where early operation is undertaken, but ankylosis is commonly an outcome of the severe grades of the condition.

Treatment.—The treatment varies with the stage of the disease. In the acute stage if the symptoms are at all severe the indication is to cut down upon the diseased area, to wash out the diseased tissue, or to establish drainage. As the focus is in the marrow, the cortex of the bone is to be trephined until the marrow is reached and drainage established. Where exact localization is not possible the bone can be trephined in the diaphysis near the epiphyseal line. The marrow should not be curetted, as it is desirable to save the endosteum. If the symptoms are slight it may be safe to delay active interference, but judgment should favor incision and drainage in all doubtful cases.

In the subacute stage it is desirable to remove the necrotic area to establish the regeneration which takes place through the periosteum. The periosteum should be separated from the bone, and in cases with extensive disease the diseased shaft removed and the inner edges of the periosteum placed in apposition, to favor the formation of new bone. The removal of this necrotic portion should not be attempted until the acute stage has passed, usually about two months after the first onset of the disease.

In the chronic stage the treatment involves the consideration of not only the removal of the sequestrum, but the filling of the remaining cavity with normal bone. As the cavity is surrounded by thick, hard bone with little vascularity, it does not readily develop new, healthy

bone growth. Sinuses persist indefinitely, the cavity being filled with granulation tissue (Nichols).[1]

The removal of the shaft as well as the sequestrum and stitching the surfaces of the uppermost sides together is indicated. In the tibia, where the fibula acts as a splint, this can be done, but where no splint of bone is present a part of the involucrum must be left. The periosteum should be applied closely to it, regeneration of bone taking place from the inner surface of the periosteum and from healthy endosteum.

When the joint is involved the treatment is conducted on the same principles. In the acute stage drainage should be established as soon as possible by free incisions. In the subacute stage where no sinus has been established the joint will need fixation and protection to check the progress of the disease and to prevent deformity. The treatment under the circumstances resembles that given in tuberculous joint affections. In the chronic stage with sinuses and sequestra, the treatment consists of the thorough drainage of bone with the free removal of the hardened bone. If the cavity necessary for complete drainage is a large one, it can be left to fill in with granulation or can be covered in with a periosteal flap.

The treatment of the deformities following infectious osteomyelitis is similar to that of the deformities following tuberculous ostitis. Forcible rectification of contracted joints, with or without osteotomy or incision, may be needed. Such operative interference should not be undertaken until the stage of cicatrization has been established.

Spine.

Acute Osteomyelitis.—The spine is not commonly attacked by this disease. In 1903 about fifty well-authenticated cases had been reported.[2]

The most common age of onset is from six to fifteen, but younger children and adults are not exempt. The process may attack either the vertebral arches or the bodies, and is of the same general character as osteomyelitis elsewhere, modified by the peculiar structure of the vertebral column. It occurs under the same conditions as those of the general process. Secondary centres of suppuration are likely to occur elsewhere in the body. The lumbar region is most frequently affected, but no part of the spine is exempt.[3]

The *symptoms* are stiffness, tenderness and pain, high fever, and much constitutional disturbance. Abscess occurs in practically all

[1] Journal of the Amer. Med. Assn., February 13th, 1904.

[2] Grisel: Revue d'Orthopédie, September, 1903.

[3] Gross: "Osteomyelitis of the Lateral Parts of the Sacrum." Deutsch. Zeit. f. Chir., lxviii, 95.

cases and the tissues around the abscess become œdematous. Although posterior abscesses are accessible, anterior abscesses are almost impossible to locate. Paralysis occurs in about one-third of the cases.

Deformity of the spine is not of frequent occurrence, because, although the process is rapidly destructive, the new formation of bone is rapid and the severity of the disease necessitates recumbency.

The mortality has been said to be as high as sixty per cent, but this cannot be accepted as accurate, as the less severe forms of the affection may often have been overlooked.

Direct incision to the bone furnishing drainage is indicated as soon as is possible. During convalescence the spine should be supported as in Pott's disease.

Typhoid Spine.—In the later stages of typhoid fever an acute, painful condition of the spine, presenting symptoms similar to those of very acute Pott's disease, occasionally is seen. Although pathological proof is wanting, it seems likely that the affection is a localized and often superficial osteomyelitis of the vertebral column. The nervous symptoms are most marked, and disturbances of sensation and paræsthesia are frequently present. Deformity is not the rule and when it occurs is small in extent. The prognosis for ultimate recovery is good and the treatment does not differ from that of acute Pott's disease.[1]

Hip.

Acute Osteomyelitis.—This location of osteomyelitis is comparatively frequent. In 758 cases of disease of the hip at the Göttingen Clinic,[2] there were 110 cases of acute infection and 568 cases of tuberculosis. This proportion is practically the same as that found by Bruns.[3]

The process may be acute and rapidly destructive or slower and less acute.

In *infants* it is rather a violent process, accompanied by high fever and much swelling about the hip. Pain and constitutional disturbance are marked. Flexion of the limb and muscular spasm are pronounced and abscess occurs in most if not all cases. The process may cause separation of the epiphysis of the femur, destruction of the head of the

[1] Könitzer: Münchener medicinische Wochenschrift, August 29th, 1899 (46 Jahrg., No. 35). Philadelphia Medical Journal, February 10th, 1900.—Frederick T. Lord: "Analysis of Twenty-six Cases of Typhoid Spine" (with literature). Boston Medical and Surgical Journal, June 26th, 1902.—R. W. Lovett and C. F. Withington: Boston Medical and Surgical Journal, March 29th, 1900.—E. G. Cutler: Boston Medical and Surgical Journal, June 26th, 1902, p. 687.—E. Fraenkel: "Ueber Erkrankungen des rothen Knochenmarks, besonders der Wirbel, bei abdom. Typhus," Hamburg. Mittheilungen a. d. Grenzgebieten, Jena.—Journal of the American Medical Association, April 25th, 1903.

[2] König: "Die spec. Tub. der Knochen u. Gelenke," xi., Berlin, 1902.

[3] Bruns and Honsell: Beitr. z. klin. Chir., xxiv., 1; xxxix., 3.

femur, or dislocation of the hip by destruction of the capsule without destruction of the head. In the latter cases the disease of the bone is probably situated a little farther from the articular surface. In each of these conditions the hip is found completely dislocated with perhaps grating in the joint. In such cases later in life a condition resembling congenital dislocation of the hip is found where the stump of the femur is loosely connected with the acetabulum. This condition is spoken of as floating *pseudoarthrosis* or *pseudoarthrose flottante*.[1] Extensive osteomyelitis of the femur may remain after the hip symptoms have been relieved by operation.

In *older children* the process is less violent and bears more resemblance to tuberculosis of the hip in its clinical aspect. The symptoms are, however, more severe. It is attended by high fever, leucocytosis, and perhaps delirium; there is much swelling, and the joint symptoms are of a very marked character. Shortening may occur rapidly and abscess is practically universal. In some cases the affection is less acute, and in these the diagnosis from tuberculosis often cannot be made until the abscess is opened and a culture made from its contents.

Coxa vara may result from the faulty union of a loosened epiphysis or from a spontaneous fracture of the neck.

The treatment of the disease does not differ from that of osteomyelitis in other joints. The hip-joint, however, may require traction or protection after operation.

In other joints the affection presents no peculiar characteristics.

Acute Arthritis of Infants.

This condition, recognized clinically since its description by Thomas Smith in 1874,[2] is now identified as a variety of osteomyelitis affecting the joints in young infants, the exact pathological history of which is not known. The onset is severe and is characterized by elevation of temperature, marked general disturbance, and local swelling about the joint, which is quickly followed by suppuration, the formation of an abscess, and disorganization of the joint, with extensive destruction of tissue unless the process is arrested by early operation. Spontaneous evacuation of the abscess may occur. In the severer cases separation of the epiphysis, dislocation, or the formation of a flail joint may result. Death may occur from septicæmia, and the prognosis is not so good in cases in which more than one joint is affected. The prognosis depends more upon the performance of an early effective operation than on anything else. The death rate has been variously given,[3] but recovery

[1] Ducroquet et Besançon: Presse Méd., No. 15. 1903.

[2] St. Bartholomew's Hosp. Reports, vol. x., 1874.

[3] Gonser: Jahrb. f. Kinderh., July, 1902.—Hoffmann: Med. Bull. Wash. Univ., September, 1902 —Whitman: "Orth. Surg.," 2d ed., p. 271.

frequently occurs in cases in which early operation is possible. Treatment should consist in free incision and flushing out of the affected joint with free drainage. The operation should be followed by fixation until the wound is closed. The hip and knee are the joints commonly affected.

INFECTIOUS SYNOVITIS AND ARTHRITIS.

An inflammation of the joints may occur in connection with acute infectious diseases, which may be acute or chronic, serous or purulent.

Etiology.—The lesions which occur are to be attributed to the presence in the joints of micro-organisms or their products, and the organisms found in the joints are either the staphylococcus, the streptococcus, or the organism peculiar to the primary disease. The affection may involve one or several joints, and attacks children more commonly than adults.

The infectious diseases in which joint complications occur [1] are as follows: Cerebro-spinal meningitis, diphtheria, dysentery, erysipelas, epidemic parotitis, glanders, gonorrhœa, epidemic influenza, measles, pneumonia, pertussis, puerperal fever, pyæmia, septicæmia, scarlet fever, smallpox, tonsillitis, typhus fever, typhoid fever, after the use of sounds and catheters, and possibly in malaria. An affection of the joints of a similar character is seen at times where no antecedent infectious disease can be identified.

In the same connection must be mentioned pyogenic infection of the joints from wounds and similar outside sources.

In consequence of some of the above-mentioned infections there arises a joint affection of another type, not to be distinguished clinically from arthritis deformans.[2] It will be considered in that connection.

Pathology.—The affection is most often manifested by an acute serous, sero-purulent, or purulent inflammation of the joint, accompanied at times by a deposit of fibrin. The process is generally most evident in the synovial membrane, and, although bony involvement by extension may occur, it is not the rule. In purulent cases there is suppuration of the synovial membrane with loss of epithelium, and in severe cases the formation of granulation tissue, fibrous degeneration, or even necrosis of the cartilage and damage to the ends of the bones and destruction of the ligaments. Spontaneous luxations may occur and ankylosis must result in the severest cases. In a great part of the cases, however, the local process runs its course without great damage, and even in suppurative cases early incision is usually resorted to before the process has accomplished extensive destruction. Less commonly these processes are chronic or subacute.

[1] For literature see second edition of this book, p. 194.

[2] J. E. Goldthwaite: Boston Med. and Surg. Journ., 1904.

Symptoms.—The symptoms vary, according to the grade and character of the infection, from those of a simple synovitis to those of a severe suppurative process.

Treatment.—In the milder cases the treatment is that of synovitis. In suppurative cases the joint should be freely opened, washed out, and drained as soon as the existence of suppuration is recognized.

The only modification of the usual free incisions in general use is to be found at the knee-joint, in which, in severe cases, it may be found advisable to make an extensive U-shaped incision, cut the patella tendon across, and fix the knee in a flexed position after the method of Mayo. In this way the joint is thoroughly drained. The patella tendon is sutured when repair is established.

Gonorrhœa.

Gonorrhœal synovitis or arthritis, and gonorrhœal rheumatism are the names most commonly applied to an inflammation of the joints occurring in the later stages of gonorrhœa.

This inflammation is acute or chronic, and is most often polyarticular.[1]

Varieties.—The commonest inflammations are as follows:

Arthralgia, without definite lesions or associated with slight periarticular lesions or bursitis.

Acute synovitis, monarticular or polyarticular, resembling acute rheumatism, with considerable periarticular swelling.

Periarticular inflammation with joint effusion absent or subordinate.

Tenosynovitis occurring about the joints, but not necessarily involving them.

Chronic synovitis, serous or purulent, occurring as a sequel to the acute forms or begins as a chronic affection. This, if prolonged, may lead to changes in the joint, such as laxity of ligaments, etc.

Pathology.—The effusion, if serous, is generally thick and may contain clots of fibrin. It may be sero-purulent or purulent. The effusion may be colored by blood. In the severer cases the joint changes may not differ from those described in the arthritis due to pyæmic processes.[2] The striking feature is the amount of granulation tissue formed. Such a process shows little tendency to involve bone or cartilage, being essentially synovial. Ankylosis is to be feared. The inflammation shows the same tendency toward fibrous hyperplasia in the joints that it does in the urethra, which, of course, tends to impair joint motion.

Etiology.—The affection has been demonstrated to be due to the gonococcus. The gonococci are found in the joint effusion in many cases. They are more likely to be found in acute than in chronic

[1] Trans. Assn. Am. Physicians, vol. x., p. 150.

[2] Wien. klin. Woch., January 15th and 22d, 1903.

cases. The gonococci may be present in the pus cells of the granulation tissue, or if in the exudate, in phagocytes or in epithelial cells free or in clumps. They may, however, not be found in the effusion or in sections of the synovial membrane. A mixed infection with pyogenic organisms may be found, or, rarely, pyogenic organisms alone may be found in the joint fluid. Suppuration of the joint is not necessarily associated with mixed infection.

Men are much more frequently affected than women. The complication rarely, if ever, occurs before the third week of the disease, and occurs in about two per cent of all cases. Involvement of the joints may occur after the passage of a sound into the urethra, in the vulvovaginitis of little girls, and in the gonorrhœal ophthalmia of babies.[1]

The joints affected were as follows in the order of their frequency in Northrup's series: Knee, 91; ankle, 57; small joints of foot, 40; wrist, 27; heel and toes, 21; elbow, 18; hip, 16; shoulder, 16; small joints of hand, 11; sterno-clavicular joint, 3; temporo-maxillary joint, 2.

The prognosis can hardly be formulated. The affection is always serious and generally slow in progress and resistant to medication. In the acute stages suppuration is to be feared, and impairment of motion, perhaps ankylosis, is not unlikely to result. Simple cases perhaps oftenest recover after a long time with practically normal motion.

The duration in Northrup's cases was:

	Cases.
One to six weeks	64
Six weeks to two months	54
Two months or more	77
Indefinite	57

Treatment.—In the acute stage the affection should be treated like other forms of synovitis and the fluid withdrawn from time to time for examination. Suppuration demands incision and drainage. Convalescent cases should be treated as if convalescent from ordinary synovitis, only with greater care.

Obstinate and persistent chronic synovitis, if in the hip, should be treated by protection, and perhaps traction by apparatus. Fixation by plaster bandages is to be used if the joint is painful. More accessible joints are best treated by free incision and flushing out with hot sterile water or hot weak corrosive solution in obstinate cases. Drainage for a few days should be kept up by strips of gauze, and the joint should be washed out daily in severe cases. In such cases incision and drainage are often followed by cessation of pain and marked improvement.

If operation is not practicable the ordinary measures in use for the treatment of chronic synovitis are to be used.

[1] Editorial. Am. Medicine, April 25th, 1903.—R. B. Kimball: "Gonorrhœa in Infants." Med. Record. November 14th, 1903.

CHAPTER VII.

ARTHRITIS DEFORMANS.

Definition.— Pathology.—Etiology.—Symptoms.—Varieties.—Frequency.—Diagnosis.—Prognosis.—Treatment.
Spine.—Spondylitis Deformans.—Pathology and etiology.—Symptoms.—Diagnosis.—Prognosis.—Treatment.
Hip.—Etiology and Pathology.—Symptoms.—Diagnosis.—Treatment.
Knee.—Symptoms.—Prognosis.—Treatment.
Shoulder.—Wrist.—Temporo-maxillary joint.

The affection is known by a multiplicity of names, of which the following are the principal ones: Arthritis deformans, rheumatic gout, chronic rheumatic arthritis, arthrite sèche, osteoarthritis, nodosity of the joints, rheumatoid arthritis, nodular rheumatism, dry arthritis, proliferating arthritis, malum senile, and chronic articular rheumatism.

The name arthritis deformans, proposed by Virchow, is used here, as it is descriptive and involves no etiological theory or pathological basis.

Definition.—Arthritis deformans is a chronic, non-suppurative affection, which attacks the joints, crippling and deforming them. Although the affection is a chronic one, it is subject to acute exacerbation. The disease is common, and affects not only man, but many other animals, such as horses, cattle, dogs and other carnivora, and even birds. The affection varies in its manifestations, as may be inferred from the various names which have been assigned to it. Some confusion has arisen in the minds of practitioners from the terminology, which has associated the affection with rheumatism, the disease having been called chronic rheumatism, chronic rheumatoid arthritis, etc. The affection is one of a distinct type with variations, and is characterized by stiffness, some pain, and discomfort of the affected joint, with gradual progress of the disease and subsequent distortion and malformation of the joints.

Pathology.—The pathology of this affection has been the subject of much discussion and is not yet understood. Some writers have claimed that it is of infectious origin,[1] others that it is dependent upon changes

[1] Schüller: Berl. klin. Woch., 1893, 865.—Dor: Comptes rend. Soc. de Biol., 1893, 899.—Bloxall: Lancet, 1896, i., 1120.—Bannatyne, Wohlmann, and Bloxall: Lancet, April 25th, 1896.—Teissier: "Du Rhum. goutteux." Lyon Méd., 1897, 169.—Charrin: "La rhum. chron. de l'infection." Prog. méd., 1894, No. 43.—Pribram: "Chr. Gelenkrheum. und Osteoarthritis Deformans," Wien, 1902, p. 95.

in the central nervous system, and others that it is due to the presence of some toxin as yet unknown. In the opinion of several observers the disease can be divided into two or more distinct affections. Further investigation is needed to determine these questions. The pathological changes are, however, characteristic and fairly well defined. They may be said to consist of fibrous degeneration of the tissue of the joints, with resulting changes in the development of scar tissues, and in the more advanced cases in the transformation of degenerative fibrous tis-

FIG. 175.—Arthritis Deformans of Knee-joint.

sues into abnormal bony growths. The process may at any stage become arrested and stationary. The affection begins in the synovial membrane, the cartilage being attacked either at the same time or but little later. The synovial membrane and capsule are congested, swollen, thickened, and in parts relaxed. If the joint is opened, in addition to the congestion of the synovial membrane one finds thickening of the villi and folds of the membrane, which may be extensive, so that an arthritis villosa may be said to exist. In some instances these enlargements may take on cartilaginous formation and even ossification, and,

if they become freed from their attachments, they may become loose bodies in the joint. In other cases the enlargements undergo a fatty degeneration, so that they have been regarded as fatty tumors. The term lipoma arborescens is applied to this condition.[1]

The cartilage of the joints becomes affected in spots and shows

FIG. 176.—Vertical Section through Part of the Bodies of Sacral Vertebræ from a Case of Spondylitis Deformans. Drawing shows the new formation of dense bone along the anterior surface which is especially marked at the intervertebral discs. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

FIG. 177.—Arthritis Deformans of Hip. (Warren Museum.)

fibrillary thinning, degeneration, and vascularization. Pannus may develop, which becomes united with the growth from the synovial membrane. In some cases in which the cartilage is covered by pannus there follows the formation of cicatricial tissue and fibrous or bony ankylosis, with possible subluxation and distortion of the joints. The

[1] Painter and Erving: Amer. Jour. of Orth. Sur., vol. i., No. 2, p. 109.

cartilage may be entirely absorbed and bare surfaces of bone left, which become thickened. In other places there may be areas of cartilaginous thickening or hypertrophy, but where interarticular pressure occurs areas of absorption of cartilage are likely to be found. In certain cases when the pressure is more gradual histological changes may take place in the cartilage in a different way. The osteoid elements in these cases apparently invade the cartilage, with the development of bone in irregular directions, the regions of the exposed bone being filled with osteoid elements, so that a layer of hard, cicatricial bone is developed.

In the *marrow* various changes may occur. Fatty and mucoid de-

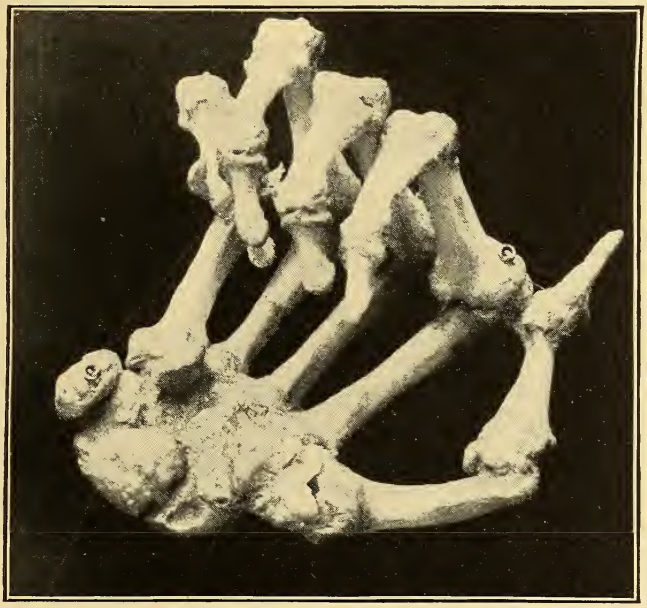


FIG. 178.—Bones of Hand Badly Deformed by Arthritis Deformans. (Warren Museum.)

generation may follow the destruction of the cartilage, giving the bone greater translucency to *x*-ray illumination, or osteoid cells may be developed and abnormal bone be found in regions where it does not belong. Irregular formation of bone may also take place in the periosteum, the fibrous attachment of the capsule, the ligaments, and the insertion of the periarticular muscles; this process is preceded by fibrous thickening. The absorption of the parts of the bone spoken of, with the changes induced by the irregular pressure, the abnormal growth of exostoses, and the consequent changes of shape complete the distortion. The distortion of the joint is also the result not only of the changes in the shape of the bones, but also in their relation to each

other. It is due partly to relaxation of the capsule in places, with contraction in other places, and to pull of the muscles from the muscular spasm reflex to joint irritation. The immobility of the joint, its altered function and the consequent development of new bone, and the inflammatory or irritative changes in the periarticular tissues and in the periosteum, all contribute to the distortion of the joint. As a rule, the capsule and capsular ligaments are the parts chiefly involved, the wearing away of the cartilage occurring only at points of interarticular pressure in a joint restricted in motion. In other cases the changes in the shape of the bones by the development of marginal exostoses are considerable. In other cases the synovial changes predominate, with the development of villi and possible pannus and cartilaginous absorption. In lighter cases the changes in the cartilage are limited to a diminution in its normal glistening appearance. It must be remembered that tuberculous degeneration of chronically enlarged synovial villi may occur, but it is to be regarded as a pathological process distinct from arthritis deformans.

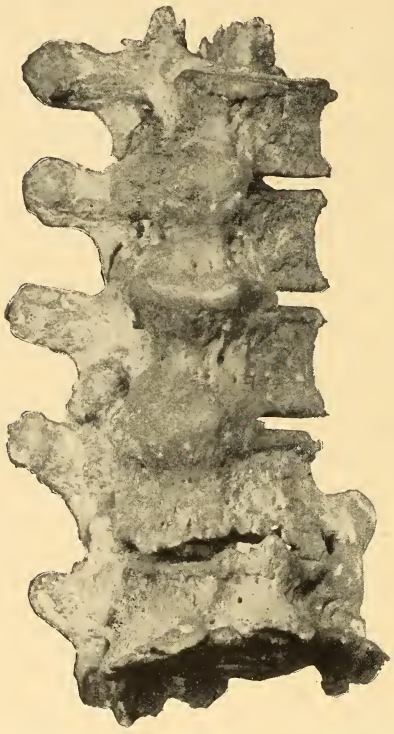


FIG. 179.—Spondylitis Deformans Showing Deposits of Bone at the Sides of the Vertebræ. (Warren Museum.)

The *muscles* controlling the joint become changed and undergo atrophy and fibrous degeneration, and certain muscles may become contracted, while others are overstretched. The periosteal muscle attachments are thickened and are likely to become the seat of the deposit of bone. The periarticular subcutaneous tissue and the fascia in the vicinity of the joint are likely to become involved in the process. In this case they are found to be œdematous, and swelling followed by hyperplasia and permanent thickening occurs. The synovial fluid in some instances, especially in the more acute stages, is increased in amount and becomes slightly turbid. Acute enlargement of the lymphatic nodes and the spleen is not often seen in the arthritis deformans of adults. Still [1] has, however, described such enlargement in a separate form of the disease seen in children. Such changes diminish or disap-

[1] Medico-Chir. Trans., 1897.

pear as the patients become older. The blood is normal in most cases, as to the percentage of hæmoglobin, the leucocyte count, and the differential count. The urine shows no characteristic changes. Goldthwait has found an increased elimination of calcium salts.

Complications are not uncommon in advanced cases, from enlargement of the heart, chronic nephritis, and the various manifestations of arteriosclerosis.

Etiology.—The etiology of the affection is not yet definitely determined. In certain cases injury is ascribed as the exciting cause, but,

FIG. 180.—Arthritis Deformans of Hip-joint Showing Shortening of Neck of Femur. Broadening of head and broadening and loss of depth in acetabulum. (Warren Museum.)

as in a majority of cases the disease develops without obvious traumatic origin, the connection between the injury and the pathological process is not evident. Some disturbance of metabolism is apparently connected with many of the cases.

Frequency and Age.—The affection is common in old age, as may be seen from the following figures, taken from the Long Island Pauper Institution in Boston. Out of 66 men between sixty and eighty years of age 12 showed marked manifestations of arthritis deformans to a degree which interfered with locomotion and activity. In none were Heberden's nodes observed. In the women's department of the almshouse, of 96 patients only 5 showed affection of the larger joints, while

12 had developed Heberden's nodes. Out of 26 cases in men, the disease made its first appearance in 7 between the ages of fifty and fifty-nine, and in 46 women in 10 between forty and forty-nine.

In McCrae's [1] series of cases the age of onset was as follows:

1–10 years	15 cases	41–50 years	28 cases
11–20 "	30 "	51–60 "	18 "
21–30 "	33 "	61–70 "	6 "
31–40 "	28 "	71–80 "	2 "

Localization.—At the Long Island Hospital the joints were involved in the first attack in the following order of frequency, according to statistics prepared by Dr. F. S. Richardson:

Wrist and hand	15
Elbow	1
Shoulder	10
Spine	2
Hip	1
Knee	25
Ankle and feet	6
More than one joint	4
Unknown	10

The onset was

Acute, obliging the patient to go to bed for a few days in	16
Subacute in	6
Insidious in	35
Unknown in	16

FIG. 181.—Ankylosis of Knee-joint Following Arthritis Deformans, Showing Osteophytes and Ossification of Ligaments. (Warren Museum.)

According to Pribram,[2] the hand was attacked in 29 per cent, the foot in 24, the knee in 17.7, the shoulder in 11, the ankle in 6, the elbow in 3, and the sterno-clavicle articulum in 1.

Garrod and Bannatyne give the order of frequency as follows: hand, elbow, cervical region, knee, ankle, jaw, shoulder, hip, sterno-clavicular joint.

Symptoms. — *Early Symptoms.* — The onset of the affection is, as a rule, gradual, and no characteristic early symptoms are noted. In a large majority of cases it occurs in older people, and females are more often affected. The early symptoms are most often a gradually increasing lack of flexibility in certain joints, which is followed by occasional pain

[1] McCrae: Journ. Am. Med Assn., October 8th, 1904, p. 1027.

[2] Alfred Pribram: "Chronischer Gelenkrheumatismus und Osteoarthritis Deformans." Wien, 1902.

after unusual exertion. Cracking of the joint is heard, which has been studied by Blodgett with the aid of a stethoscope. The stiffness of the joint when overused in the early stages is most evident after a period of rest. In this early stage it may be a long period before the disease is recognized, and the symptoms may be confused by a numbness or crackling or burning sensation in the joint, sometimes associated with vasomotor disturbances which cause redness of the skin. In a certain number of cases during this early stage, before the marked appearance of characteristic changes, a slight elevation of temperature and an increase of pulse may be observed, which may persist for some time. In addition to the general discomfort, there may be also present impairment of the general condition, shown by loss of appetite and wakefulness. The gradual increase of the symptoms is accentuated at times by slight acute attacks, induced generally by accident or follow-

FIG. 182.—Arthritis Deformans in a Child of Ten, of Long Duration. Most of the joints affected. Showing enlargement of elbows, wrists, and ankles, and flexion deformity of knees.

ing overuse. Long periods of remission with slight improvement or relative quiescence of symptoms often occur, but on the whole the disability increases.

In other cases the invasion is somewhat acute, so that the affection resembles what is ordinarily known as acute rheumatism, differing from it, however, in the absence of profuse perspiration and markedly high temperature. A sensation of swelling and actual swelling of the joint, with some pain on movement, with perhaps some limitation of the extremes of motion, follow the changes described.

Swelling.—The swelling varies greatly both in amount and in its location. In the milder cases of the most chronic type at an early stage little or no swelling is present, this symptom being gradually developed later. Swelling of the synovial tissues, with perhaps synovial effusion, is likely to be recognized at a comparatively early stage of the affection, and is of importance. Later there occurs a fusiform swelling, consisting of œdematous periarticular tissues, the capsule, and the ligaments, along with some inflammation of the synovial membrane.

Stiffness.—The limitation of motion in affected joints is due partly

to the mechanical obstructions to motion produced by the pathological process, and partly to muscular spasm, which, however, is a much less prominent factor than in tuberculous disease, except when the process has become extensive.

Distortion.—This swelling may diminish, leaving the joint distorted by the muscular spasm, the cicatricial contraction of some structures, and the relaxation of others, along with the periarticular thickening of the periosteum and other tissues which have become the seat of bony deposit. Distortion of position is usually manifest in the flexion of the joints, but in the hands the distortion may be manifested as a hyperextension of the fingers, with deviation to the ulnar side in connection with the distortion and alteration in the shape of the articular ends of the bone.

FIG. 183.—Hand in Arthritis Deformans in a Child Ten Years Old.

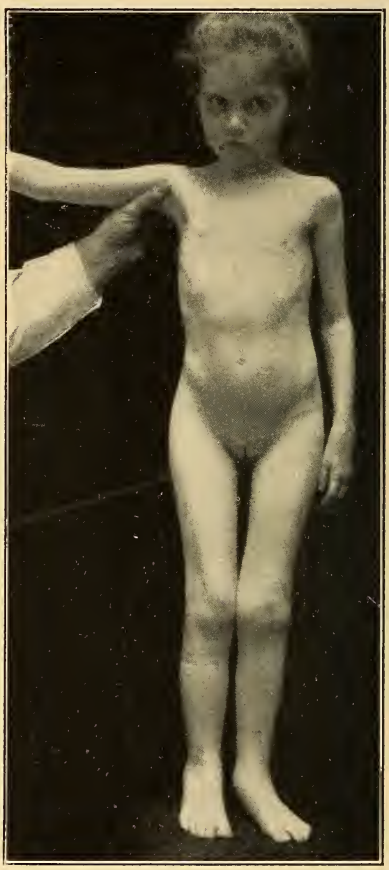


FIG. 184.—Arthritis Deformans in a Child Involving nearly all the Joints. Comparatively early Stage.

Skin and Fascia.—The subcutaneous tissue and the fascia undergo changes, which are characterized at first by swelling, which is followed by thickening and contraction. In certain places in the fascia, nodules

may be felt, which may be the occasion of great discomfort when they occur in the plantar fascia, which is occasionally the case. Bands of contracted fascia and subcutaneous thickening in the hands may cause a contraction in flexion of the ulnar fingers described by Dupuytren.

Varieties.—Several varieties of this affection will be met, which may be grouped as follows:

1. Several joints may be involved, with swelling and without marked exostoses. This variety attacks all ages, but is more frequently seen in the middle-aged or young. This type has been called the polyartic-

FIG. 185.—Arthritis Deformans following Gonorrhœa. Considerable boggy swelling of and effusion into the joints. Ulnar deviation at proximal phalangeal joints. Painful during active stage only. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

ular, atrophic, or chronic rheumatoid type. It has also been called nodular arthritis or arthritis nodosa.

2. A monarticular type, attacking chiefly the larger joints, may occur. In this form exostoses develop and the joint becomes enlarged by the abnormal development of bone. The process is of slow development and is seen in older patients or in patients whose tissues may be regarded as prematurely senile. This group is called the monarticular, hypertrophic, or osteoarthritic variety. A sharp distinction between these types is not readily made, and they may be regarded as different stages of the same process, the first occurring in younger cases, the second when the progress is slower and the changes are more completely developed.

3. A third type, more commonly seen in women and children, is

characterized by a stiffening of several joints, with synovial swelling and a late development of changes in bone. This has been termed the fibrinous type, arthrite fibreuse (arthritis fibrosa), and ankylosing arthritis. Goldthwait has described this as an infectious type,[1] but McCrae[2] is inclined to believe that it is not improbable that all forms may be regarded as infectious or the result of a toxin as yet undiscovered. For that reason the term infectious has been avoided by us.

4. A fourth type of the affection is frequently seen in elderly women, the chief characteristic of which is to be found in "*Heberden's*

FIG. 186.—Hand in Arthritis Deformans, Showing the Enlargement at the Middle of the Middle Finger. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

FIG. 187.—Arthritis Deformans of Long Standing (Heberden's Nodes). Marked enlargement of the distal phalangeal joints. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

nodes." This term is applied to a form of arthritis deformans attacking the fingers at the last phalangeal articulation. Pathologically the process is the same as that seen in other articulations, namely, fibrous changes in the synovial tissues, the formation of pannus and absorption of the cartilage, periosteal thickening, periarticular swelling, and later the irregular formation of bone, with subluxation and displacement and alteration in the direction of the bones forming the joint.

The earlier writers classed the affection as a form of gout, but, although similar distortions are seen in gout, characteristic Heberden's

[1] J. E. Goldthwait: Bos. Med. and Sur. Jour , January 28th, 1897, and 1904.
[2] McCrae: Jour. of Amer. Med. Association, xliii., 15, pp. 1027–1038.

nodes do not have chalkstone deposits. The deformity occurs more commonly in women than in men, appearing after middle life. It is usually accompanied by similar changes in other joints, but it may be limited to the finger-joints alone. The fingers are not very painful, though there may be in the early stages slight pain and a prickling and itching sensation.

The treatment of these joints is similar to that of the treatment of arthritis deformans in other joints, and is both constitutional and local.

The course of the affection is usually slow, though there may be long periods when but little change is noticeable.

Pathological changes similar to those described above are also seen in a chronic joint affection following gonorrhœa, and also after the eruptive diseases, such as scarlet fever and influenza. These manifestations are similar to milder grades of arthritis deformans. Whether they should be classified as distinct or whether they are the exciting cause of a chronic process which may end in arthritis deformans is not determined. They are entirely distinct from the suppurative affections caused by pyogenic germ infection, and are perhaps due to the fact that a previous infection has weakened the patient, rendering him subject to the influences of a toxin or whatever cause develops the changes seen in arthritis deformans.

FIG. 188.—Arthritis Deformans of Long Standing in an Old Woman. Dislocation of the proximal phalangeal joints. Ankylosis of middle and terminal phalangeal joints. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

FIG. 189.—Double Hallux Valgus and Hammer Toes. Associated with arthritis deformans.

Diagnosis.—When an adult is affected with a chronic progressive affection of several of the joints, accompanied by swelling, slight pain, absence of suppuration, and with an increasing deformity and an enlargement, partly of bone and partly of the capsule, with distortion, a

diagnosis of arthritis deformans is easily made. In the less developed cases, in which the affection is monarticular or occurs in children, it is at times difficult if not impossible, without a careful observation of the case, to determine whether the case is tuberculous or not. A diagnosis can be made by incision of the joint and inoculation experiments. In children as well as in adults chronic non-suppurative polyarticular affections are more probably non-tuberculous.

A diagnosis is aided by an *x*-ray examination, which in advanced tuberculous affections shows marked focal destruction.

In arthritis deformans the bone may be either thickened or show irregular osteophytes if the process is of the eburnating type, or there may be an increased translucency if the cellular change has not advanced to bone formation.

Treatment.—The literature of the treatment of this affection has been extremely unsatisfactory until recently. The administration of iodide of potash, iron, cod-liver oil, and antacid and antirheumatic drugs was formerly recommended as a routine treatment. Of late the uselessness of such medicinal treatment has been generally recognized, and more rational methods have taken its place. It goes without saying that an early diagnosis is of importance in order that the patient may be placed under proper conditions before the disease has made great progress. The treatment should be both constitutional and local. Among the constitutional measures one of the most important is diet.

Diet.—It was formerly supposed that the affection was of a gouty nature, and that a meat diet, and especially one including red meat, was to be prohibited. This was based upon the theory that the affection was of a rheumatic character and due to an excess of uric acid. The theory having been disproved, it is now believed that the affection is either caused or influenced by malnutrition, and for that reason a restricted diet is to be avoided. If meat is well digested and is satisfactory to the patient, it is manifestly better that the patient should not be deprived of it. The diet should be carefully looked after in each case and should be directed according to the individual digestion of the patient. The patient should avoid an excess of every variety of food. A starchy diet or a diet containing a great deal of sugar should be avoided in case any intestinal disturbance follows. It should be remembered that it is not only the stomachic but also the intestinal digestion which must be watched. As the affection is influenced by the impairment of the general metabolism, indigestion should be carefully avoided. A glass of one of the laxative mineral waters before breakfast is desirable where there is any tendency to constipation.

Clothing.—The clothing of such patients should be regulated in such a way as to furnish a greater protection from sudden changes in temperature and to allow absorption without too rapid evaporation of

perspiration. This object is best reached by the use of woollen undergarments.

General Routine.—It is hardly necesary to add that, so far as the general conditions go, a regular life under the most favorable surroundings possible is to be aimed at, that extreme fatigue or mental strain is to be avoided so far as practicable, and that so far as possible the unfavorable surroundings and conditions are to be eliminated. The rest of the general treatment consists in properly regulating the diet, in promoting elimination by the skin, kidneys, and intestines, and by the use of tonics when required.

Exercise.—It is particularly important that all means of elimination of waste products should be encouraged. It is for this reason necessary not only that the intestines should be normally active, but it is also desirable that both the perspiration and kidneys should have an opportunity for free action. As the latter are influenced by increase of fluid in the patient's diet, it is to be carefully prescribed. Exercise promoting a free perspiration is also desirable. This in weaker patients can be done by the judicious use of hot baths and hydrotherapeutics, but, where exercise is possible, perspiration which results from muscular effort is more beneficial.

Drugs.—General tonics should be given, in the shape of strychnine if a nerve tonic is desired, and in case on blood examination it is found that an anæmia exists, iron is indicated. Aspirin has some effect at times in relieving pain.

Local Treatment.

The object of local treatment is to promote the circulation and to stimulate the tissues around the joints which are undergoing a process of change, which must be regarded as a degeneration rather than an inflammation.

Rest.—When the joints are strained and congested, protection from strain is desirable, but absolute rest and fixation are to be avoided except temporarily during the existence of acute pain. Even at this stage the joints should be rested rather than fixed.

Treatment by Rest.—When the joints are in an irritated condition, as indicated by pain, tenderness, or discomfort during and after motion, restriction of use is for a time advisable. This can be furnished by one of the mechanical appliances described for preventing joint motion in tuberculous diseases of the joints or by the application of a removable plaster support. Such restriction of joint motion is to be employed for as short a time as possible and to be discontinued as soon as the acute stage is past. Motion is to be regarded as a normal function of the joint, and degenerative changes take place more quickly in unused

joints, and hence in this condition, prolonged fixation is to be avoided as probably detrimental.

Exercises.—The principle of treatment is that the joints should be used within the arc of their possible motion freely, but that strain, violence, and excessive use should be avoided. As far as possible the arc of motion should be increased, but this should not be done at the expense of irritating the joint. Exercises for the purpose just described can be given in the form of passive manual manipulation or by the aid of such mechanical appliances as have been devised for the purpose of moving the joint without the use of the muscles. These should not be pushed to the point of causing much pain. Various forms of pendulum exercises can be employed and the well-known Zander appliances are to be used, but, being complicated and expensive, they are beyond the reach of general practitioners. Simple apparatus can be devised which will answer this same purpose. As the joints improve, carefully prescribed active exercises can be added to and take the place of the passive exercises. Exercises, either active or passive, given for this purpose, are best done when the body weight is removed from the joint.

Hot Air. Local.—The local application of dry, hot air, carried to a point of from 300° to 400° F., has proved to be of benefit in the treatment of arthritis deformans in many instances, especially in the lighter cases. The limb should be placed in a properly constructed oven, wrapped in flannel, and the heat raised to the highest comfortable point. This treatment should continue from twenty minutes to an hour. The treatment, although often productive of great benefit, should be applied with discretion and the patient watched, as it is at times exhausting and may irritate the joint. In the stage of acute inflammation it is not so beneficial as at other times. The heating of the joint should be followed by rest, and, in cases that are not acute, massage following the heating may be of use.

Hot Air. General.—Hot-air baths for the whole body may be given by means of a metal cylinder lined with asbestos, which is long enough to include the body up to the armpits and is heated by gas, gasoline, or electricity. The patient lies in the cylinder and the temperature is raised to 350° or 400°. The heat should be run up rapidly in order to secure the necessary degree of physiological effect as quickly as possible. The pulse and temperature rise, and an exposure to this heat from twenty to twenty-five minutes is sufficient. The method is described as being of greater use than the local application, and is suited to the treatment of the severer cases.

Electric Light Baths.—The use of the combined heat and light given off by a number of incandescent electric light bulbs, placed inside of a box similar to the ordinary cabinet bath, has been found of use. It

is said that free perspiration is induced at a lower temperature than when the heat alone is used without the light.

Massage.—Manual massage is of assistance in stimulating the local circulation and promoting the absorption of some of the swelling. It is a remedy often of use, but sometimes exaggerates the symptoms. It should be used with great gentleness, and the joint, if acutely irritated, should be very lightly rubbed, the attention being directed to the tissues about the joint. As the tolerance of the joint increases it may receive more massage, but many cases are rendered more acute and painful by the use of massage applied for too long a time. It is useful only in so far as it is quieting to symptoms, and should be done with gentle passive movements. Mechanical vibratory stimulation is of use in connection with, or replacing massage. It may be given as a general treatment for purposes of stimulation, and locally it serves as a sedative to muscular irritability.

Electricity.—Electricity may be of use in the form of galvanism applied once or twice weekly, or of static electrical application made more often. The Morton wave current and some of the high-frequency currents applied either locally or generally may be of use with these or may replace them.[1]

Hydrotherapy.—The use of hydrotherapy in this disease is at times of undoubted benefit. The combination of a change in surroundings, careful diet, and massage, in connection with the water treatment, frequently unite in improving the patient's general and local condition. The use of warm alkaline baths may be varied by the use of baths of hot mud, a mode of treatment for which special arrangements are necessary. The subject of hydrotherapy is too extensive to be entered upon here,[2] and in the treatment of arthritis deformans it is to be regarded as a measure for both general and local treatment, at times of much value. The recent establishment of hydrotherapeutic institutions in the larger cities serves to make this treatment more available.[3]

Treatment by the Application of Hot Sand.—Burying the affected joint in hot sand is a method of applying dry heat. The heat cannot be as well regulated as the hot-air treatment, but it will be found to be efficacious.

Vacuum Treatment.—Placing the joint within a glass case and exhausting the air by means of a pump has been tried with benefit in several cases. It is a means of causing passive hyperæmia.

Treatment by Passive Congestion.—Bier has recommended a method of treating arthritis deformans which is specially applicable for the knee and wrist. This consists of setting up a local passive congestion, which

[1] Skinner: Jour. Amer. Med. Assn., October 8th, 1904.
[2] Baruch: "Hydrotherapy," New York, 1899.
[3] Pratt: Boston Medical and Surg. Journ., 1904.

can be accomplished by applying a bandage from the foot up to the knee, leaving the knee uncovered and applying an elastic bandage directly above the knee, sufficiently tight to cause a congestion of the joint. This congestion should not be so great as to give rise to a cold condition of the surface. The tissues should become blue and the patient should suffer some discomfort, but pain should not be experienced. This congestion should be allowed to continue for from seven minutes to half an hour, and massage should be applied to the joints afterward. The method is of advantage, but does not take the place of dry heat, though it may be used in certain cases in which dry heat is not applicable.[1]

Operative Treatment.

As functional use of a joint affected with deformity is essential to recovery, when deformities exist in the lower extremity one of two things is necessary. Either the limb must be straightened by apparatus or by operative means, unless gymnastic exercises and stretching can be used for the purpose.

Mechanical Correction of Deformities.—The same methods that are used in the correction of deformities of tuberculous disease can also be applied to the deformities following arthritis deformans, with the exception that the latter occurs more commonly in adults than in children and greater difficulty is met in correcting these deformities without an anæsthetic. On the other hand, greater force can be used without danger of suppuration in arthritis deformans than is possible in the tuberculous affections.

Removal of Obstructions.—The operation consists of forcible correction with or without tenotomy, after the removal of any obstructive fringes or lipomata if such interfere with the motion of the joint, or the removal of exostoses if these act as obstructions. It is manifest that when many joints are involved operative interference is to be limited to the most important joints or the joints most important for locomotion.

Goldthwaite and Painter have demonstrated by their work the feasibility of opening the knee-joint and removing obstructing fringes, and it is manifest that where an exostosis prevents motion, and its removal will improve the function of the joint, it is desirable that it should be done. It should, however, be remembered that in many of these the affection is not simply limited to an alteration in the synovial membrane.

Summary.—The less severe cases are likely to be relieved by being put upon a proper regimen in the matter of diet, exercise, sleep, baths,

[1] A. H. Freiberg: Amer. Jour. of Orth. Sur., vol. ii., No. 1, p. 50.

etc. In addition to this, electricity, massage, douches, hot-air baths, and the other methods intended to improve the local circulation are likely to be highly beneficial.

The severer cases demand more careful treatment and supervision, and the following will serve as the type of a desirable routine: The diet should be generous. The patient should rest in bed ten out of the twenty-four hours. Tonics and mineral waters are used. Hot-air or electric-light baths to the whole body are given two or three times weekly. Electricity or vibratory stimulation is given practically daily. Passive movements are given to the affected joints with a view to increasing their range of motion.

The treatment of arthritis deformans in its various stages requires not only patience on the part of the surgeon, but much care on the part of the patient. Relief can be offered in almost all instances, and a stay of symptoms may be expected to follow in a certain number of favorable cases. It is to be remembered that the affection is essentially chronic and that the natural course of the disease is interrupted by as yet unexplained periods of remission. It is, therefore, difficult to examine critically the principles of treatment or the results in any individual case, but it is certain that attention to the patient's general condition, followed by the improvement which is brought about by such measures as are influential in improving the circulation, makes the use of the limbs possible with less discomfort; the correction of deformity, the protection of the limb from strain, and the placing of the limb in such a position, by operation or by apparatus, that locomotion is not accompanied by discomfort, unite in aiding the joint to recover its usefulness.

Arthritis Deformans in Children.

In children the characteristics of the disease do not vary essentially from those in adults. Clinically one finds the same type of manifestations seen in adults in some cases, while others show a type chiefly found in young children, which was described among others by Still and is sometimes spoken of as Still's disease.[1] In such cases the symptoms begin generally before the second dentition, the earliest onset reported being in a child fifteen months old. In this type the cartilaginous and bony changes are slight, and progressive and deforming swelling with thickening of the joint and periarticular structures takes place. The affection is polyarticular; pain is not a predominant symptom, but glandular and splenic enlargement is common. Recovery may occur in these cases. The treatment does not vary from that in adults.

[1] Still: Med.-Chir. Trans., 1897.—Spitzy: Zeit. f. Orth. Chir., xl., 4, 699 (with bibliography).—Goldthwaite: "Infectious Arthritis." Boston Med. and Surg. Journ., 1904.

SPINE.

Spondylitis Deformans.

Osteoarthritis of the spine,[1] ankylosing inflammation of the spine,[2] rigidity of the spine, spondylose rhizomélique,[3] neuropathic curvature of the spinal column,[4] kyphose hérédo-traumatique, Bechterew's disease of the spine,[5] Steifigkeit der Wirbelsäule, etc., are names which have been applied to the condition.

The essential character of this affection is a chronic and progressive stiffening of the spine, accompanied by pain.

Pathology and Etiology.—When the process involves the spine the same differences in types may be seen as those described. The affection may be characterized by stiffness without much bony change, or the bony change may be marked and the deformity distressingly noticeable. When the spine is completely stiffened it is accompanied usually by some loss of motion in the articulations of the rib, corresponding to the fibrinous arthritis or ankylosing arthritis seen in other joints.

The pathological process found is that of arthritis deformans modified by the peculiar structure of the vertebral column. The ligaments and interarticular cartilages degenerate, and the former become the seat of bony deposits, while the latter may hypertrophy at the edges and these marginal hypertrophies become ossified, forming a lipped edge to the vertebra. The interarticular cartilages degenerate and the vertebræ become fused together. A deposit of new-formed bone occurs along the front and sides of the column, binding the various vertebræ together.

In other cases the hypertrophic element is wanting and fusion of the vertebræ occurs by disappearance of the intervertebral discs without marked deposit of new bone.

The hips and shoulders are involved in the process in a certain proportion of cases, showing the changes characteristic of arthritis deformans. The peripheral joints may or may not be simultaneously affected.

The etiology is not different from that of arthritis deformans else-

[1] Goldthwaite: Bost. Med. and Surg. Journ., 1902, p. 299.

[2] Strümpell: Deut. Zeit. f. Nervenheilkde., 1897, 338.

[3] Marie: Revue de Méd., 1898, xviii., 285.—Vollheim: Inaug. Dissertation, Jena, 1902.—Siven: Zeit. f. klin. Med., xlix.—Rurah: Am. Journ. Med. Sci., November, 1903 (with bibliography).—Simmonds: Fortsch. a. d. Gebiete d. Roentgenstr., vii., 2.—Brodnitz: Zeitsch. f. orth. Chir., xii., 142.—Pribram: "Chr. Gelenkrheumatismus," etc., Wien, 1902, p. 158 (with bibliography).

[4] Neurol. Centralbl., 1899, vii., 294.

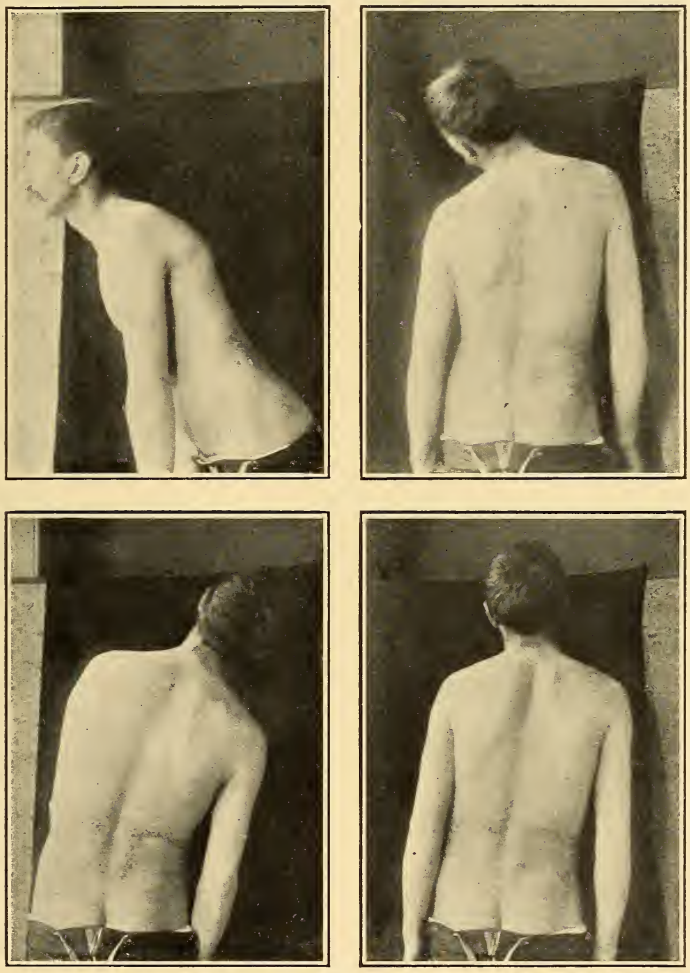
[5] Neurol. Centralbl., 1893, 426; Deutsch. Zeit. f. Unfhkde., 1897, xi., 326.

where, except that gonorrhœa seems to be quite frequently an antecedent of the affection.[1]

There has been a tendency to recognize two types of the affection:

Flexion Forward.
II

Flexion to Left.
III



IV
Flexion to Right.

II
Best Standing Position.

FIG. 190.—Arthritis Deformans. Involving spine from upper dorsal to mid-lumbar region (J. E. Goldthwaite.)

(1) described as the Bechterew type,[2] in which the other joints are generally not affected, and in which a neuropathic origin has been assumed

[1] Bradford: Ann. of Anat. and Surg., 1883, vii., 6.

[2] Strümpell: Deutsch. Zeit. f. Nervenheilkunde, 1897, iv.

to exist; (2) the Strümpell-Marie type,[1] with involvement of shoulders or hips, and in this type the pathological basis is found in an ankylosis of vertebræ and an ossification of ligaments.

Later consideration of the subject has tended to the opinion that the two types are not distinct, but simply the natural variations of a process which is characterized in general by marked differences in its manifestations.

FIG. 191.—Arthritis Deformans Following Gonorrhœa Involving Spine and Many Other Joints. Spine perfectly rigid except upper cervical region. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

Symptoms.—Stiffness and pain in the spine are the characteristic symptoms. Stiffness at first is partly due to muscular irritability, but later may become the result of ankylosis.

Motion is generally restricted in all directions, but bending to one side is freer than to the other at first. Lateral deviation of the spine is likely to be present. The physiological dorsal curve may be increased and the lumbar curve generally obliterated, after a while the whole spine forming a bow backward. The gait is careful and simulates that of Pott's disease.

Pain is present chiefly in the spine, but also in the peripheral ends of the nerves, as in Pott's disease. It is generally more marked on one side than on the other. It may be a subordinate symptom or it may be so acute as to be aggravated by every jar, and it may be paroxysmal. Pains of a neuralgic character, areas of disturbed sensation, and even paralysis may be present in the legs and arms. These are due to the compression of the nerve roots.

The patient walks more or less bent over by the dorsal kyphosis, and in stooping the motion is entirely from the hips. In lying down the curves are not affected or obliterated in the later stages. The lower

[1] Bechterew: Deutsch. Zeit. f. Nervenheilkunde, 1899, xv.

spine is generally first affected and the cervical last. In the severest cases the spine is stiff from the sacrum to the occiput, and permits no more motion than would an iron rod. In the severer cases the ribs are ankylosed at their junction with the spine, and the chest wall scarcely moves in inspiration, or it may be entirely stationary and the breathing is wholly abdominal. As the cervical vertebræ are usually the last to be affected, motion of the head may be possible after the dorsal and lumbar regions have become rigid. In less severe cases the spine is not involved to the whole extent, but marked stiffness without angular projection exists in a portion of the column. Stiffening and flexion of the hips is present in some of the cases, and leads to a most distressing gait in which the whole body is carried bent forward.

The course of the disease is chronic in the extreme, and its duration covers many years. The bone inflammation has no destructive tendency and accomplishes nothing more than stiffening the vertebral column. The impairment of the general health consequent upon this is generally not so severe as one would anticipate.

The **diagnosis** of the affection can be made by recognizing the rigidity of the entire vertebral column without the angular prominence of Pott's disease, nor does the latter affection so stiffen the whole column, but only the diseased region. Pott's disease involving the whole or a large portion of the vertebral column would soon lead to very marked results in its destructive tendency. The immobility of the ribs is a pathognomonic sign of the affection, and the involvement of other joints would merely confirm one's opinion of the character of the disease.

Prognosis.—It need hardly be said that the prognosis is unfavorable as to complete recovery. Early cases may pass into a quiescent stage by means of proper treatment and the pain subsides. Most cases are improved by support and fixation. If the other joints are involved, the patient's condition is deplorable.

Treatment.—The general measures likely to be of use have been described. In the acute stage the use of fixation is indicated. A plaster or leather jacket applied without suspension is the best means of obtaining this. As the acute symptoms quiet down, massage is of value. The spine should be protected by a brace so long as it is painful and irritable. The use of manipulation to ward off the approaching ankylosis is harmful and undesirable at all stages of the affection.

HIP.

Arthritis deformans of the hip-joint is an affection which is not uncommon in patients above the age of forty-five. It may occur as a monarticular affection or in connection with a simultaneous affection of some of the other joints.

Pathology and Etiology.—When affecting the hip it is known as senile coxitis, malum coxæ senile, etc. It begins in many cases insidiously, while in others, and especially monarticular cases, it follows after a fall upon the trochanter. From the shortening of the head and neck in these cases it was long supposed to be an impacted fracture of the neck of the femur, but the shortening results from the absorption of the head and is in every way like the pathological changes found in the insidious cases. The affection may occur in adolescents and children.[1]

Symptoms.—The affection begins with pain in and about the joint, often shooting down the course of the sciatic nerve at the back of the leg instead of down the front, as in epiphyseal ostitis. At this stage the affection very closely simulates sciatic neuralgia. Movements of the joint beyond a certain arc are painful, and a noticeable limp is present. External rotation and hyperextension are particularly painful movements to the patient, and if the leg is manipulated a distinct creaking is sometimes felt which is most noticeable when the movements are most painful.

Muscular atrophy of the limb comes on and the nates of the affected side are flaccid and flattened, and apparent shortening from flexion and adduction is present in the diseased limb, as well as true bone shortening. Muscular fixation is at first not a prominent symptom, except in very sensitive conditions of the joint, but the arc of motion gradually diminishes, until finally the joint may become entirely stiff in perhaps a normal position, or perhaps adducted or flexed. In the earlier stages abduction and apparent lengthening of the limb may be present as in hip disease.

The position which the limb assumes in the more advanced cases of the disease is one which is calculated to be most misleading, especially when the affection has followed a fall upon the trochanter. The limb may be rotated outward and, with the apparent shortening, presents almost a complete picture of an impacted fracture of the neck of the femur. In other instances the thigh may be flexed and adducted as in hip disease proper.

Diagnosis.—The affection is likely to be confused with sciatica and with other forms of inflammation of the hip-joint.

In sciatica the limitation of motion is governed by the amount of pain produced by the movement of the sensitive parts and by the tension on the nerve, and therefore differs from that resulting from true hip-joint disease. Flexion is usually free to a certain limit, but impossible beyond this, and if the leg is held extended on the thigh this is particularly noticeable. In sciatica, hyperextension is not interfered with, nor rotation nor lateral motion. The diagnosis from true hip disease is based on the history of the affection, the *x*-ray appearances, and

[1] Bruns: Beitr. z. klin. Chir., xl., 650.

on the patient's age—tuberculous epiphyseal ostitis being less common in adults.

Treatment.—Morbus coxæ senilis or arthritis deformans demands treatment, first to relieve the pain, and secondly to correct the deformity.

The symptom of pain is rarely so great as to cause disability. In such cases hot baths, massage, galvanism, hot packs, and the other measures mentioned are often of use. The use of crutches and canes will often be needed. The deformities which follow this affection are usually those seen in hip disease, but they are more gradual in development. They are persistent and obstinate, but are amenable to proper mechanical treatment, such as is used in the deformities of hip disease.[1]

Joint irritation from overuse is to be met here as elsewhere by rest to the joint. The use of the protection splint described in hip disease may temporarily be necessary when the joint is acutely irritated.

More is to be gained ordinarily by gradual correction by mechanical means than by forcible straightening in this class of affections of the hip.

KNEE.

The knee is one of the large joints most frequently attacked by this affection.

Symptoms.—Pain, irritability, and a sense of stiffness, especially after sitting a while, are the most frequent early symptoms. After walking a while the knees feel freer, but they stiffen up after rest and are also painful in the morning on waking. Going up- and down-stairs is difficult and irritating. The whole condition at first seems rather an irritability than anything more serious, and the patient is apt to disregard the discomfort and to do considerable walking, on the ground that walking relieves the stiffness. The discomfort is increased by cold and wet and by overuse. Acute attacks of pain and swelling may occur.

In some cases the affection progresses insidiously and gradually without acute attacks. On examination in the early cases the synovial membrane is somewhat thickened and the surface depressions of the knee are filled out. There is perhaps a little fluid in the joint, and movements are almost always attended by a more or less marked grating. This phenomenon is due chiefly to hypertrophy of the synovial fringes, which are rubbed together when the joint is moved. It is also probable that the same sensation can be produced without any structural change by mere dryness of the articular surfaces.

In the progressive cases and in those of longer standing the painful symptoms are more marked, and heat and tenderness are prominent, according to the acuteness of the symptoms.

[1] "Senile Coxitis." N. Y. Med. Jour., December 15th, 1888.

At times there is on walking a sensation of catching in the knee, as if something had been squeezed between the bones. This points to an hypertrophied condition of the synovial fringes.

The first limitation of motion is a resistance to complete extension, and the tendency to a flexed position is marked, favoring ankylosis in this position.

In general, the tendency of the affection is toward greater and

FIG. 192.—Enlargement of Knees and Ankles from Arthritis Deformans in a Child of Ten. Disease of long duration.

greater impairment of the joint motion, with wasting of the muscles and atrophy of the skin, so that in the advanced stages one can see a stretched and shining skin tightly drawn over the deformed and distorted joint.

The **prognosis** depends largely upon the degree of change in the joint surface when treatment is begun. If it is slight, as shown by

moderate thickening and soft grating on motion, much is to be expected from the prevention of overuse and the regulation of the circulation in the knee. If the changes in the joint are advanced, and especially if other joints are showing signs of a progressive involvement, the outlook is unfavorable; not that life is likely to be shortened, but that serious disability of the joint most often results.

Treatment.—When pain is present rest is very strongly indicated. A few days will generally suffice to quiet the acute symptoms. Dur-

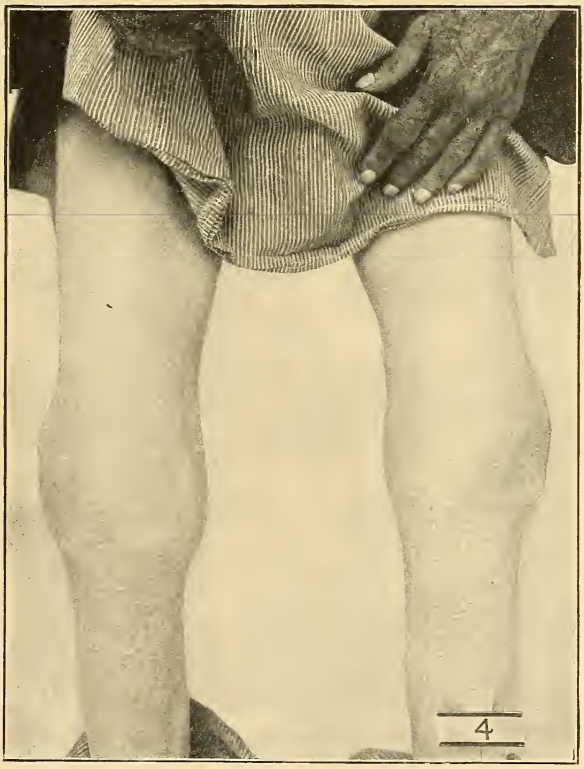


FIG. 193.—Arthritis Deformans, Bony Enlargement of Knees with Effusion. Palpable fringes. Limitation of motion. Crepitus and pain on motion. (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

ing the quiescent stage, the local measures described above should be used. If pain is excessive, one has to face the dilemma of continuing motion which is excessively painful or of allowing the patient to rest and keep the joint still, by which process one is likely to favor the stiffening of the joint, if it is continued for too long a time. For short periods, however, there is no risk, and sometimes much to be gained by complete rest to the affected articulation.

When ankylosis of the knee in a faulty position has resulted from arthritis deformans, brisement forcé is to be tried for its rectification, as described for the correction of ankylosis after tumor albus. It is not, of course, to be expected that motion will be present in the joint in its new position, for the structural changes must have already been extensive to have induced the deforming ankylosis, yet some motion may be preserved in the joint.

FIG. 194.—Arthritis Deformans Following Gonorrhœa. Effusion into left knee-joint with subluxation of the tibia. Considerable thickening of soft parts. Motion mostly limited by pain. [Involvement of many joints.] (By the courtesy of the Department of Surgical Pathology of the Harvard Medical School.)

SHOULDER.

The shoulder is a frequent seat of this disease, when it occurs in the monarticular form. When one shoulder alone is affected the history of injury is usual, but in the polyarticular forms this is not so common. The disease may first manifest itself to the patient as a slight attack of joint pain, tenderness, and stiffness, and from this condition pass into the slow chronic course, with occasional exacerbations, or it may begin insidiously. The amount of pain varies; it is more or less persistent, but not constant, and is dull and heavy and usually worse at night. Stiffness appears at this time with pain, at first only slight, and noticed in forced movements, when the arm is raised above the level of the shoulder.

As the disease progresses the muscles waste, and in severe cases to a very noticeable degree. A creaking sensation, both on active and passive motion, is almost always found by placing the hand over the joint. Later in the disease, when the characteristic osseous changes occur, the arm can be raised but a short distance from the side, and the loss of muscular power is great. When the changes in the joint have taken place a characteristic appearance of the joint is found. The head of the humerus is more prominent in front of the joint, while behind is a depression as if the head of the bone was displaced forward, while the shoulder droops.

The treatment does not differ from that described for the other joints.

WRIST.

The wrist is a common seat of this affection, with the ordinary symptoms of pain, swelling, stiffness, creaking, etc. When deformity has occurred, the wrist is generally flexed, and the distal ends of the radius and ulna are enlarged and project backward. Frequently the hand is adducted, this often being associated with a similar distortion of the fingers.

Arthritis deformans of the wrist should be treated on the principles already indicated for these affections.

The *temporo-maxillary joint* is occasionally affected by arthritis deformans. Massage in these cases can be given by the finger in the mouth, as the affected joint is more easily reached from the inside.

CHAPTER VIII.

OTHER AFFECTIONS OF THE BONES AND JOINTS.

Sprains.—Spine.—Spondylitis traumatica.—Rupture of spinal ligaments.—Hip.—Knee.—Lesions of the tubercle of the tibia.—Ankle.—Wrist.
Chronic synovitis.—Hip.—Knee.—Hypertrophy of villi.—Loose bodies.—Lipoma.—Dislocation of semilunar cartilages.—Cysts.—Trigger knee.—Irritability secondary to flat-foot.—Ankle.—Shoulder.—Elbow.—Wrist.
Bursitis.—Hip.—Knee.
Habitual dislocations.—Patella.—Shoulder.—Symphysis pubis.
Tumors of bones and joints.—Syphilis.—Spine.—Gout.—Ostitis deformans.
Arthropathy.—Spine.—Hip.
Hæmophilia.—Scurvy.—Secondary osteoarthropathy.—Growing pains.
Actinomycosis.—Spine.—Myositis ossificans.—Ankylosis.

SPRAINS.

The name sprain is used to designate a common condition caused by wrenches and twists, and occasionally by blows to the joints. It is, in general, the result of some sudden force moving the joint beyond its normal arc of motion. The injury may be most marked: (1) to the ligaments, which may be injured or torn; (2) to the synovial membrane, which may become the seat of an acute synovitis; or (3) to the tendons surrounding the joint, causing a tenosynovitis. Any one of these or any combination of them may exist in a given case.

The *pathology* of the affection requires no especial consideration, the changes found being simply those of reaction to trauma modified by the especial tissue affected.

The *symptoms* consist of pain, more or less severe, and tenderness, localized at the point of the chief injury; in the more superficial joints ecchymosis of the subcutaneous tissue appears, followed by swelling. The function of the joint is accompanied by pain, often severe enough to prevent its use. A period of greater or less disability follows, during which the symptoms diminish in severity, and in favorable cases entirely disappear. In other cases a condition of swelling, irritability, and impaired function persists, spoken of as "chronic sprain." Sprains are not frequent in children, in comparison to adults.

The joints most frequently sprained are the ankle and wrist.

The *diagnosis* from fractures is important and is to be made with great care.

The *prognosis* is favorable and progress is hastened by treatment.

Two lines of *treatment* are recognized. In one the joint is fixed by a splint or plaster bandage, and disuse of the joint is depended upon to

hasten repair and the absorption of the blood and serum poured out. When the process has passed the acute stage, massage and douches are generally used to stimulate the circulation and hasten recovery.

In the other method of treatment the attempt is made directly after the injury to stimulate the local circulation by massage, etc., and thus hasten the repair while the joint is used in moderation. The latter method is painful, but recovery seems to be hastened by it, and the circumstances of the patient are frequently the determining factor in the choice of methods.

The latter method is carried out as follows: Immediately after injury the joint should be baked in a hot-air oven for half an hour and massaged for a few minutes, or massage alone should be given as soon after the accident as possible. Massage should then be given twice a day for periods of half an hour each, which at first will be decidedly painful, and the joint should be used moderately. During the early part of the treatment the joint should be supported by an elastic flannel bandage or adhesive plaster strapping. The massage periods should gradually be separated by longer intervals, and may alternate with douches of hot followed by cold water to the affected joint. Various modifications of the treatment may be used; hot-air baths may take the place of one daily massage treatment in the early stages. Vibratory massage is of use.

When massage follows the treatment by immobilization, the method does not differ from that described.

Spine.

Sprains of the Spine.—After a severe wrench or twist of the spine or after some accident causing extreme motion in one or another direction, a condition of pain and disability ensues, presenting much the same symptoms as those accompanying sprains in the other joints. Stiffness, pain, and perhaps lateral deviation follow a painful period, during which recumbency is generally necessary. As such cases are most often treated by recumbency on a sagging mattress, followed by sitting up as soon as possible, these cases are apt to drag on through a long convalescence and often to pass into the chronic condition described as "neurasthenic spine." It is better that cases with this history should be recognized as chronic sprain of the spine, to which nervous symptoms have been added.

When the chronic stage has been reached there is but little tendency to spontaneous improvement, and the diagnosis from spondylitis deformans may be difficult.

The treatment of sprains of the spine should consist in the immediate application of a plaster jacket or recumbency on a gas-pipe frame until convalescence is established. Then should follow massage and

progressive use of the spine, protected by the jacket or a spinal support as long as movement is painful.

If the patient has reached the stage of chronic irritability of the spine, fixation by a jacket is indicated, followed by the course of treatment just described for convalescent cases.

Traumatic Spondylitis.—Following accident some weeks or months after, there develops at times a painful and stiffened condition of the spinal column, accompanied by a rounded kyphus of greater or less extent, which remains as a permanent condition. Partial paralysis may occur.

Kümmell,[1] who originally described the affection, assumed that there existed a rarefying osteitis, but this assumption has not been sufficiently supported by post-mortem evidence, and it seems likely that the condition is the outcome of partial and compression fractures[2] of the vertebral bodies and changes in the shape of the bodies induced by their altered static relations.[3] Certain cases described under this heading are perhaps cases of arthritis deformans following trauma and wrongly classified, and some may be classed in all probability as osteomyelitis. The prognosis does not differ from that of spondylitis deformans. The treatment consists in rest and fixation of the spine.

Rupture of Spinal Ligaments.—By severe traumatism to the back, causing extreme flexion of the spine, there may occur a rupture of the posterior spinal ligaments between two of the vertebræ.[4] A kyphus is present in the erect position, which disappears on lying down. It is accompanied by pain, which is more acute in the upright position. The diagnosis is made from the signs described. The treatment consists in fixation of the spine by a brace or jacket in the corrected position.

Hip.

Sprains of the hip are manifested clinically as synovitis of that joint and are described in that connection.

Knee.

On account of the strength of the muscles and ligaments controlling the joint, gross ligamentous and muscular injury is rare at this joint, the results of trauma being generally expressed as synovitis.

Lesions of the tubercle of the tibia have been described by Osgood,[5] in which, after a sudden strain falling upon the partially extended knee, swelling and tenderness of the tubercle have followed, associated

[1] Deut. med. Woch , 1895.

[2] Reuter: Arch. f. orth. Chir., ii., 2, 137 (with full bibliography).

[3] W. A. Lane: Practitioner, May, 1901.

[4] Painter and Osgood: Boston Med. and Surg. Journ., January 2d, 1902 (with bibliography).

[5] R. B. Osgood: Boston Med. and Surg Journal, January 29th, 1903.

with pain on complete extension of the leg. The condition is seen chiefly in boys at or about the age of puberty.

This condition would seem to be due in some cases to an inflammation of the bursa under the patella tendon,[1] and in others to an injury of the partly ossified and vascular epiphysis of the tubercle of the tibia. *X*-ray appearances are apt to be misleading, as during the normal ossification at this age the tubercle appears to be torn loose from the tibia below.[2] Only when there is a marked difference in the radiographs of the two knees and the tibial tubercle is displaced upward is one justified in diagnosticating any displacement of it by force. The treatment consists of fixation.

Ankle.

On account of its flexibility and its constant liability to twists, the ankle is the commonest location of sprains. These may take the form of injury to the ligaments, the joint membrane, or the tendons. The location of the tenderness, swelling, and pain on manipulation will serve to identify the anatomical location of the injury.

The treatment consists either in fixation in a stiff bandage or, what is in most cases advisable, in immediate massage or hot-air baths, or both. Massage should at first be given twice a day, and should be deep and thorough. Moderate use of the foot in walking is desirable from the first, except when it is excessively painful or when there is severe ligamentous injury. Walking may be rendered less painful by the use of the adhesive plaster strapping described. As improvement progresses the massage is given less often and douches of alternating hot and cold water are added or substituted.

Chronic Sprain.—In many cases the treatment is too soon discontinued after sprains, and a tenosynovitis or subacute inflammation of part of the synovial sac may persist and be accompanied by local heat and tenderness. It matters not so much how long after a sprain local heat is found in the ankle-joint; it is a most important sign and indicates the need of rest.

In other cases fixation has been continued too long, and wasting of the muscles and disturbance of the local circulation and innervation have induced a condition of irritability.

In such cases the treatment consists of measures to stimulate the local circulation and the careful and graduated resumption of use.

Wrist.

Sprains of the wrist may affect either tendons, ligaments, or synovial membrane. The treatment does not differ from that already described.

The sprains of other joints do not require especial mention.

[1] Lovett: Report Boston City Hospital, series viii., 1897, p. 345.

[2] R. W. Lovett: Phila. Med. Journ , January 6th, 1900.

CHRONIC SYNOVITIS.

Chronic serous synovitis is also known by the names of dropsy of the joint, hydrarthros, hydrarthrosis, hydrops articulorum chronicus, etc. As a rule, pathological changes are present in the synovial membrane of a character about to be described; but certain cases show no obvious pathological changes beyond increase of fluid for a long time.

Apart from the cases in which chronic serous synovitis is (1) merely the continuance of the acute condition, its cause is to be sought (2) in the presence of some mechanical irritation (such as hypertrophied synovial fringes, loose bodies, etc.), (3) in the presence of some infectious process (such as gonorrhœa or syphilis), or (4) in connection with some general disturbance (such as arthritis deformans, hæmophilia, etc.). Intermittent synovitis should be mentioned as not coming under any one of these heads.

The pathological changes in simple chronic synovitis are represented by increase of vascularity and thickening of the synovial membrane, with hypertrophy of the synovial villi. The subsynovial tissue thickens in cases of long standing along with the capsule, and the ligaments may become weakened and stretched.

Intermittent synovitis, also called intermittent hydrops, is a well-recognized but rather infrequent affection, accompanied by no definite pathological changes, except perhaps a little laxity or thickening of the joint capsule.

The knees are most often affected, but it has been recorded in other joints. No etiology has been formulated for the condition, the sexes being equally affected and the cases pretty evenly distributed through adult life. A case in a girl of nine has been reported. The characteristic of the affection is a non-inflammatory serous effusion occurring at more or less regular intervals, lasting a few days and disappearing spontaneously, to return again and again.

No satisfactory treatment has been formulated.

Hip.

Synovitis of the hip may occur in children or adults. It may follow any of the causes producing synovitis, but the common clinical antecedents are either trauma, rheumatism, or gonorrhœa. Its importance clinically is its resemblance in children to tuberculous hip disease.

After a fall or during a rheumatic attack, pain, lameness, muscular spasm, flexion deformity, night cries, and muscular atrophy may be present for a while. These symptoms may disappear so rapidly that one is led to infer that synovitis has been present rather than tuberculosis or acute osteomyelitis.

Twenty-one cases coming to the clinic of the Children's Hospital in

1897 and 1898, which presented at that time some or all of these symptoms, were found in 1901–1902 to have entirely recovered. These were part of a series of ninety-five cases coming in those two years with a diagnosis of "hip disease" or "synovitis of the hip." The duration of symptoms in most of these cases had been less than two weeks at the time of examination. Atrophy was present in more than half, limitation of motion in all, lameness in all. Complete recovery occurred in these cases within one to four weeks in half of the cases.[1] In the other half the time of recovery was slower or could not be formulated.

In children the diagnosis of synovitis of the hip-joint should be made only when recovery has occurred in a few weeks and has proved permanent.

Treatment.—In children cases of synovitis of the hip-joint are to be treated in the same way as cases of tuberculous ostitis.

Cases in adults, which are clearly to be recognized as synovitis, should be treated by rest to the joint, including, if necessary, either traction or protection by apparatus, followed by massage and stimulation of the local circulation. And every care should be taken to guard against using the unprotected limb too soon.

Knee.

Chronic Synovitis.—Chronic serous synovitis is at times the sequel of an acute or subacute attack. In such a case the acute symptoms gradually subside, leaving a joint somewhat thickened and containing fluid. If the condition persists the muscles become weakened and relaxed, and lateral mobility may be present. The weakness of the muscles is itself a source of danger and may lead to further synovitis.[2]

At other times the chronic synovitis is the result of an irritation caused by loose bodies in the joint, displaced semilunar cartilages, hypertrophied synovial fringes, or lipoma arborescens. The continued strain on the knees induced by flat-foot is at times a cause of chronic synovitis. At other times it exists in connection with constitutional disease, such as syphilis and gonorrhœa, and the intermittent form must be mentioned.

The treatment of the chronic form which has lasted over from the acute stage consists in fixation if heat, pain, and tenderness are present, along with compression by bandaging or strapping over the front of the joint with adhesive plaster. This fixation should be followed by massage, hot-air baths, and douches to restore the circulation, along with the gradual resumption of use.

[1] "Diagnosis of Hip Disease." Boston Med. and Surg. Journ., August 14th, 1902.

[2] Hoffa: Berl. klin. Woch., xli., No. 1.—Lovett: Orth. Trans., xi., 274.—Tenney: Annals of Surgery, July, 1904.

If the synovitis exists as the result of mechanical irritation, the irritating cause should be removed by operation. If flat-foot is present it should be corrected by plates.

As a symptom of constitutional disease, treatment of the systemic

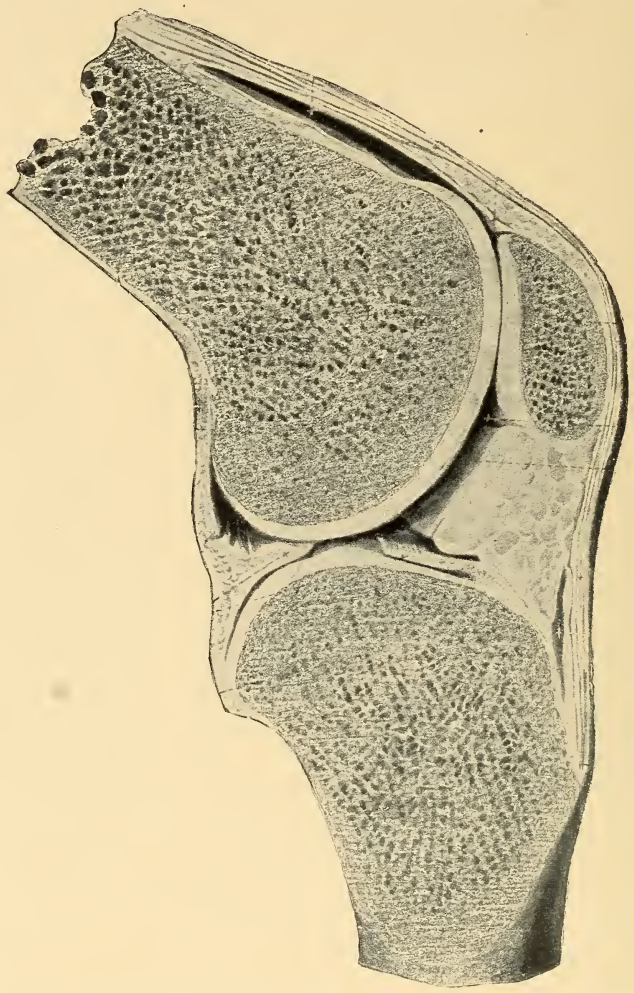


FIG. 195.—Right Knee-joint Bent. Sagittal section. Joint surface slightly separated, showing the infra-patellar fat pad, and the bursa under the patella tendon as well as the extent of the joint synovial membrane. (Fick.)

condition is indicated. In resistant cases in which the diagnosis is not clear, the joint should be opened, explored, and any irritating cause removed.

Hypertrophy of the Synovial Villi.—This affection is a frequent cause of chronic synovitis. As the result of a synovitis, or in connection with continued strain of the knees as in flat-foot, or in arthritis

deformans, hypertrophy of the synovial fringes occurs to an extent that makes of them foreign bodies. As such they are a source of continual irritation in the joint. The symptoms caused by them are pain, effusion varying at times, creaking, occasional catching, and some swelling of the joint membrane, with perhaps tenderness.[1]

The treatment at first should consist of fixation in the severer cases, and compression by plaster strapping over the front of the joint in the milder cases. Douches, massage, and the measures suited to the treatment of chronic synovitis should follow. Flat-foot should be corrected and the knee in general placed under the most favorable mechanical conditions possible. If this does not control the affection, the joint should be opened by an anterior incision on one or both sides of the patella, the interior of the joint inspected and explored, and the projecting fringes removed with sharp scissors or a knife. The bleeding is generally slight. The joint may or may not be irrigated, according to the amount of bleeding; the capsule should be stitched and the skin wound closed. The joint should be fixed for two or three weeks, after which passive motion and graduated use are begun.

FIG. 196.—Double Chronic Synovitis of Knees.

Loose bodies in the joints are found most often in the knee, but occasionally in other articulations. The other names for the condition are loose cartilages, joint mice, floating or movable bodies in joints, etc. They can be divided into classes, according to their structure, as follows: fibromatous, lipomatous, chondromatous.

They are formed in one of the following ways:

(*a*) As the fibrinous residue of an exudation or blood clot.

(*b*) As lipomata formed in the joint (see Lipoma of the knee-joint).

(*c*) As broken-off osteophytes in arthritis deformans.

(*d*) As hypertrophied or degenerated synovial tufts (see Hypertrophy of synovial villi).

(*e*) As marginal ecchondroses broken off, as in arthritis deformans (see Arthritis deformans).

[1] Painter and Erving: "Chronic Villous Arthritis." Am. Journ. of Orth. Surg., November, 1903, p. 109.

(*f*) As encapsulated foreign bodies, such as bullets and needles.

(*g*) As bits of cartilage or bone chipped off by traumatism or

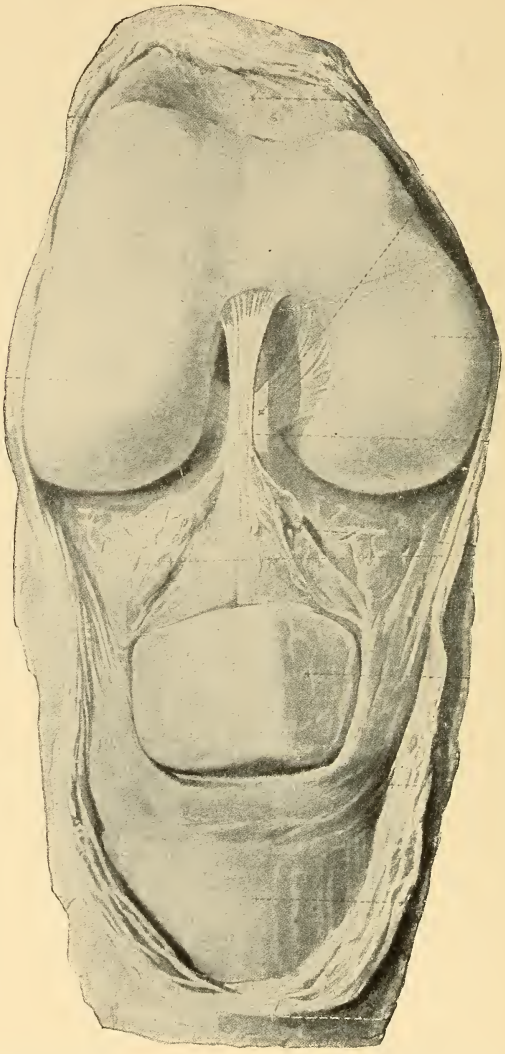


FIG. 197.—Right Knee-joint Flexed. Seen from the front. Front part of capsule with patella and quadriceps tendon are cut above joint and turned down. Between the condyles is seen the ligamentum mucosum, running from the sides of which are seen the alar ligaments. (Fick.)

loosened by a degenerative process, the result of traumatism.[1] The

[1] Lefebre: Thèse de Paris, 1891.—Ranzier: Rev. de Méd., 1891, p. 30; Trans. Path. Soc., 1896, xlvii., 177.—Whitman, Pediatrics, 1899, vii., Nos. 4 and 5 (with bibliography).—Painter and Erving: Boston Med. and Surg Journ., cxlviii., No. 12.

fact that a fall may be the cause of this variety of loose body has been clearly proved.

Loose bodies lie free in the joint or are attached by a slender pedicle. They may vary in size from that of a small pea to that of a horse chestnut, and are of all shapes. The smaller ones are most often shaped like melon seeds or are irregularly round, while the larger ones are more regularly round, concavo-convex, or spherical. Sometimes they are facetted and crowded together like the carpal bones, and again they are mulberry-shaped or pyriform. In one joint they may appear singly or in great numbers, and they may vary a great deal in size in the same joint. Over four hundred have been removed from one knee-joint. Next in frequency to the knee comes the elbow, and all of the larger joints are liable to contain these bodies. In external appearance

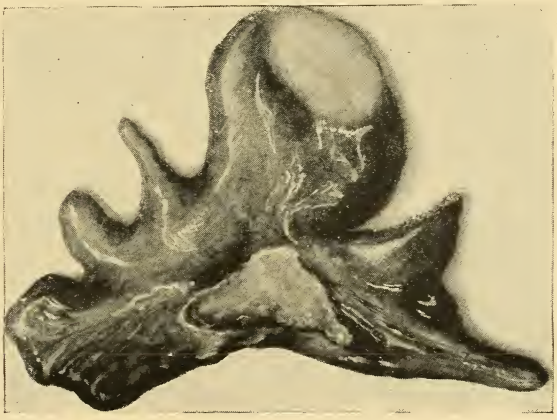


FIG. 198.—Lipoma from Knee-joint. (C. F. Painter.)

they are whitish or yellowish, and vary from a soft consistence to a bony hardness. On section they show either a plain fibrous structure or a fibrous sheath enclosing a mass of fat. Again, the structure is of hyaline or fibro-cartilage, ordinarily without corpuscles, or of bone tissue, most often without Haversian canals. Frequently they present a combination of two of these forms.

They are often found in connection with the changes known as arthritis deformans, and also in joint disease of various types. They may be found in connection with joint tuberculosis. In certain cases no cause can be assigned for their occurrence.

In a majority of cases the first intimation to the patient that anything is wrong is that while in the act of walking or stooping he is seized with such agonizing pain in the knee that he may fall to the ground, in many cases overcome with the sensation of faintness and sickening pain. At times this pain subsides almost immediately, and the patient is able to

walk within a few minutes; but at other times the joint remains fixed in a position of more or less flexion, and any attempt to move it is attended with very severe suffering. In any event, such an occurrence is apt to be followed by an attack of synovitis lasting several days. Up to this time the joint may have been normal and given no trouble, or it may have been the seat of chronic inflammation. These attacks are likely to be repeated without any assignable cause. On manipulation of the joint with the fingers it is often possible to detect a loose body,

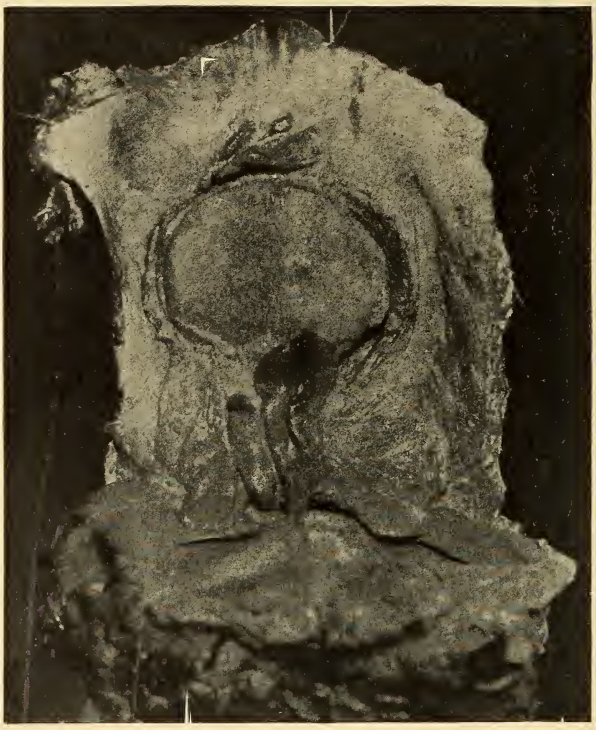


FIG. 199.—Infrapatellar Pad Showing Tabs. Left knee. (Tenney.)

which shifts its position and is found first in one part of the joint and then in another. The most common spot where they can be detected externally is in the pouch over the external or internal condyle of the femur. They are felt as smooth, slippery bodies under the skin, which evade the fingers' grasp with surprising readiness. Occasionally they may be found over the tibia inside the ligamentum patellæ, and when one of these substances has been found it is desirable to see if others are present in the joint. Sometimes it is impossible to detect any loose bodies from the outside, and the history of the case must be depended upon.[1] In some cases the attacks are of very frequent occurrence,

[1] Hoffa: Deut. med. Woch., March 3d and 10th, 1904.

while in others it is only at intervals of several weeks or months that the joint gives any trouble.

With repetition of attacks the joint becomes more tolerant and the synovitis less severe. In cases in which arthritis deformans is present as the cause of the loose bodies, the history of the attacks is less typical. The patient, however, experiences in a measure the same sudden catching of the joint, and movement of the affected knee is painful, restricted, and attended with a particularly distinct grating.

Finding a movable body which can be slipped from place to place by manipulation establishes the diagnosis.

In cases in which the loose body cannot be found, one must depend largely upon the history, making, however, frequent examinations under different conditions with the hope of ultimately detecting the foreign body.

The diagnosis between loose bodies, hypertrophied synovial fringes, and dislocation of the semilunar cartilage is often a difficult one to make, and dependence must be placed chiefly upon tenderness in a very small spot over the head of the tibia as establishing the probable occurrence of dislocation of one of the semilunar cartilages. Diagnosis has frequently to be made by exploratory incision.

Treatment.—In cases in which the loose body gives but little inconvenience and is kept from passing between the ends of the bone by a knee-cap, it may not be advisable to undertake operative treatment. In other cases, especially in arthritis deformans, the joint may have become so much impaired by the disease that even if a foreign body were removed little would be gained. In the great majority of cases, however, inasmuch as the disease occurs in otherwise healthy persons, mostly young adults, any operation which does not entail serious risk is advisable.

The operation is performed as follows:

The loose body having been found, a needle is passed through it from the outside to steady it, and it is then cut down upon by careful dissection until it is exposed and removed. After the removal of the body originally detected, the joint should be carefully examined to see if others are present. There is, of course, a slight tendency to the reformation of these bodies after one or more have been removed.

Lipoma.—Fatty growths may form in the joints, acting as foreign bodies and causing chronic or recurrent attacks of acute synovitis. Although other joints are not exempt, the common seat of occurrence is in the knee.

The occurrence of such growths in the knee-joint has been described in the form of the lipoma solitarium of König and as the lipoma arborescens of Müller.

The lipomata vary in size, being sometimes as large as an egg, and

are attached to the synovial membrane by a pedicle. In shape they may be regular or irregular and are studded with small tabs of fatlike tissue. They are frequently the result of trauma, and are formed either by the intrusion into the joint of the perisynovial fat tissue through a slit in the synovial membrane, or they are the result of inflammatory hyperplasia of the articular adipose tissue[1] or of the synovial villi.[2] Once formed, such a mass acts as a foreign body, and clinically a swollen joint is found with little or no effusion. The function is imperfect and pain may be present, and the joint is liable to lock in partial extension. The swelling is chiefly noted at the side of the patella tendon. The

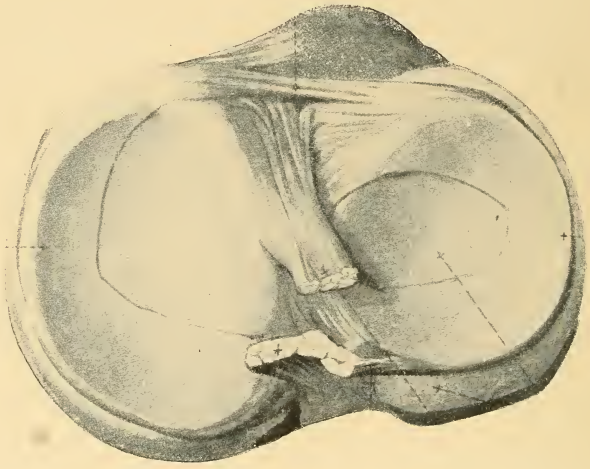


FIG. 200.—Tibial Joint Surfaces of Knee Seen from Above, Showing Semilunar Cartilages. (Fick.)

diagnosis from hypertrophied villi and similar conditions is difficult and often to be made only on exploration. The treatment consists in the removal of the mass.

Dislocation of the Semilunar Cartilages[3] (Hey's Internal Derangement).—The affection is nearly always traumatic in origin and consists in the tearing loose from its tibial attachment of the internal or external semilunar cartilage. The internal is the one most frequently displaced. This is probably for two reasons: first, because it has less mo-

[1] Hoffa: Journ. Am. Med. Assn., September 17th, 1904, p. 795.

[2] Painter and Erving: Boston Med. and Surg. Journ., March 19th, 1903 (with literature).—Stieda: Beitr. z. klin. Chir., xvi., 285, 1896.

[3] Hey: "Practical Observations in Surgery," 1803.—W. Bromfield: "Chirurgical Observations," 4 cases, vol. ii., 1753.—Tenney: Annals of Surgery, July, 1904 (with bibliography).—Ferd: Archiv f. Orth., i., 2, 1903.—Bovin: Abst. Am. Journ. Orth. Surgery, vol. i., p. 224.

bility on the tibia than the external; and secondly, the motion most likely to displace it forcibly is outward rotation of the tibia on the femur, or, what has the same effect, inward rotation of the femur on the tibia. It is probable that some looseness of the ligaments of the knee is associated with the injury to the cartilage. It must be remembered that the knee is not a strictly hinge joint, but that in extension the leg rotates outward upon the thigh, especially at the end of extension, when a quick outward rotation of the tibia occurs, locking the leg in complete extension.

A sudden wrench or twist in slight flexion is the accident most often causing displacement of these cartilages.

The *symptoms* are in a measure similar to those caused by loose bodies, and similar to, but generally rather more than, those caused by hypertrophied synovial fringes and the like. The patient, by some vio-

FIG. 201.—Three Right Internal Semilunar Cartilages Showing Fracture Opposite Internal Lateral Ligament, Upper Surface. (Tenney.)

lent muscular effort or by some sudden twist, as in kicking football or falling from a horse or carriage, wrenches the knee and finds it impossible to extend it fully, and walks with it bent in the way described, suffering much pain. This sudden locking of the joint, so far as extension is concerned, is almost the only characteristic symptom of internal derangement; but generally on examination one finds a protrusion of one of the semilunar cartilages. This establishes the diagnosis, and a sharp attack of synovitis of course follows such a severe injury to the joint.

In some instances much tenderness can be found over the inner tuberosity of the tibia where none is present over the outer tuberosity.

The most marked cases happen after some serious wrench to the joint. Nevertheless, cases occur in which the cartilage is perhaps only relaxed, and in these a much less painful locking of the joint arises. The affection is masked in many patients by the severity of the acute

synovitis which follows the injury, and the true character of the accident may not be learned for a long time afterward unless its history is most carefully inquired into, the condition in this case passing for a simple traumatic synovitis. One occurrence of the accident predisposes to subsequent attacks. Lateral mobility of the knee is likely to exist in cases of long standing.

This dislocation affects, for the most part, persons between twenty and fifty years of age; men are much more frequently affected than women; it rarely occurs in children.

Patients who are liable to the displacement soon learn the manipulation of reduction themselves. The knee should be bent to its fullest extent; the tibia should then be drawn away from the femur as far as possible, to separate the joint surfaces, at the same time rotating the tibia inward or outward as the internal or external cartilage is displaced, and then the leg should be extended quickly but not forcibly to its fullest extent, while the surgeon manipulates with the thumb the situation of the semilunar cartilages, especially if any undue prominence should be felt. An anæsthetic is very often necessary or advisable. The reduction in exceptional instances cannot be effected, but commonly, and specially with the use of an anæsthetic, reduction takes place easily and a distinct click is heard in many cases.

FIG. 202.—Semilunar Cartilage of Right Knee, Showing Effects of Long-Continued Friction. (Tenney.)

The cartilage may after reduction become united to the tibia by its former attachments or it may remain loose, to cause further attacks. It may be simply torn from its tibial attachments and remain attached as before at its two ends, or it may also be torn across in the middle, and the free end may cause trouble by acting practically as a loose body. Finally, entire detachment of the torn piece may occur, in which case it becomes a loose body of the cartilaginous class.

The injuries found in 128 operations for the relief of injured semilunar cartilages are as follows:[1]

[1] Tenney: *Loc. cit.*

	Internal.	External.
Torn from or near anterior attachment	23	3
Transverse tear at or near lateral ligament	38	
Longitudinal split, incomplete	16	1
Longitudinal split, complete	8	..
Turned into intercondylar notch	3	1
Loose	23	3
Cystic	1	1
Ossified	..	1
Doubtful	1	5
	113	15

The treatment after the original accident is reduction of the displaced cartilage, followed by the usual treatment for the acute synovitis which ensues.

If the attacks recur, especially on slight cause, it is likely that the cartilage has been permanently loosened from its attachments and will be in all probability a source of further trouble. The treatment may under these circumstances be mechanical or operative.

1. *Mechanical Treatment.*—Although the use of knee-caps with pads beside the patella, elastic bandages, etc., may prove of use in preventing in part future attacks, they can hardly be recommended as a form of treatment on account of the great inconvenience attending their use, and the fact that they are to be regarded as palliative rather than curative.

The mechanical treatment advocated by Shaffer[1] for this condition is as follows: The treatment is the application of an apparatus to the thigh, leg, and foot, allowing only the hinge motion, thus preventing, at least in large measure, the slight rotation at the knee occurring in extension of the leg. The apparatus also is arranged by a stop-joint at the knee to prevent complete extension of the knee. It consists of an outside upright attached to the boot and reaching to the upper part of the thigh, and an inside upright reaching from the upper thigh to the upper part of the calf, and a pad is placed over the inner aspect of the knee. The object of this treatment is, by preventing harmful motions and positions for some months, to produce a reunion of the cartilage to its proper attachments and a return of the ligamentum patellæ to its proper length.

2. *Operative treatment* is, as a rule, surer, quicker, and more acceptable to the patient. The joint is opened inside or outside of the ligamentum patellæ, according to the cartilage displaced, by a vertical incision. The joint should be explored and the loose part of the cartilage removed. The joint capsule should be stitched and the wound closed. Fixation should follow for two or three weeks, after which passive motion and massage should be commenced.

[1] Annals of Surgery, October, 1898.

Cysts of the Knee-Joint.—Cystic swellings in connection with the larger joints, especially the knee-joint, occur at times.[1] These swellings are found from time to time in the neighborhood of the knee-joint, generally in the popliteal space. At first there is nothing to suggest their connection with the joint in any way, for the cyst may be at a considerable distance from the joint. There may be no fluctuation to be obtained between the joint and the cyst, nor can the fluid from the cyst be pressed into the joint; yet such cysts, as a rule, connect with the joint.[2]

The affection is found most often in early and middle adult life. The diagnosis from bursitis is often difficult. Extirpation of the sac is the only treatment likely to be of use.

Trigger Knee.—The so-called *trigger knee*, described also as genou à ressort or schnellendes Knie, is characterized clinically by a disturbance in extension of the leg. Extension is normal until about 160° is reached, is then completed with a snap and forcible jerk, during which there is also outward rotation of the tibia. It is not connected with any disease of the knee-joint nor any obvious abnormality save looseness of the ligaments. The cause is evidently a disturbance of the movement of the semilunar cartilages, particularly the external, which is caught between the joint surfaces and suddenly freed, producing the jerk described. The prognosis in children is good, depending upon tightening of the ligamentous structures with or without treatment. Mechanical treatment is apparently not necessary, at least in children.[3]

Irritability Secondary to Malpositions of the Foot.—Certain malpositions of the foot may result in pain, irritation, and synovitis of the knee-joint, when the knee is affected only secondarily. Such disturbances occur in flat-foot, pronated foot, and shortening of the gastrocnemius muscle. The consideration of this subject will be taken up later.

Ankle-Joint.

Chronic Synovitis.—Chronic synovitis is most likely to be the outcome of the acute condition which for some reason has not properly recovered. In cases of long standing the circulation and innervation of the foot and leg become impaired, and swelling and congestion occur in connection with pain, tenderness, and impaired use. Malpositions of the foot may occur, the most common being a limitation of dorsal flexion. In simple chronic synovitis motion is generally but little limited and not very painful, or but slightly so, so that weakness, swelling,

[1] St. Bartholomew's Hospital Reports, vol. xiii., p. 245; vol. xxi., p. 177.

[2] Cent. f. Chir., 1898, p. 585.

[3] Trans. Am. Orth. Assn., vol. x., p. 40.—Thiem: Monatsch. f. Unfallheilk., 1896, p. 182.—Rölen: *Ibid.*, 1898, 377.—Nasse: Deutsche Chir., Lief. 66, Heft 1, p. 299.—Cotton: Journal Boston Society Medical Sciences, May, 1899.

and stiffness of the joint with occasional pain are the only symptoms complained of.

Tenosynovitis, which may exist alone or in connection with chronic synovitis, gives rise to swelling around the tendons; there may be some puffiness of the skin, heat, hyperæsthesia, and pain on certain movements of the foot; but extreme change in contour of the ankle is not present, and the pain is chiefly that of apprehension. In manipulating the foot a creaking at the painful spot may be felt, and this spot itself is sharply localized, and as a rule is not over the joint, but in the course of the tendons.

Treatment.—If heat, pain, and irritability are present, protection from weight-bearing by the use of crutches is indicated, and in the severer cases fixation of the joint by a plaster-of-Paris bandage is desirable. Compression is of value, and this can be obtained, with some degree of fixation, by surrounding the front and sides of the ankle-joint with a series of overlapping straps of adhesive plaster, each of which starts under the sole of the foot, passes obliquely over the top of the tarsus, and up behind the ankle. Applied under moderate tension, this dressing is an efficient and comfortable support.

Following this stage of the inflammation, the gradual resumption of use is indicated, along with measures to stimulate the general circulation, such as douches, massage, vibratory massage, hot-air baths, and Bier's congestive treatment.

If slight valgus position exists incidental to weakened muscles, it should be treated. If limitation of dorsal flexibility of the foot is present, it should be corrected by stretching the gastrocnemius muscle.

Shoulder-Joint.

Chronic synovitis of the shoulder is an affection existing either as a sequel of an acute attack, the result of some injury, or as a slow, persistent process, beginning with slight symptoms easily disregarded.

The earliest symptom to attract notice is stiffness, observed particularly in forced movements, as in placing the hand on the head, etc. Pain is a variable symptom.

A slight fulness about the joint may be detected at this time, the humero-pectoral groove being indistinct, and the depression below the acromion obliterated. Although an increase of surface temperature may often be detected, its absence is of little importance, the joint being so thoroughly covered. As the disease progresses, the case presents an exaggeration of the early symptoms; motion becomes more restricted, swelling increases as effusion takes place, the shoulder appearing broader, and elevations may replace the natural depressions. Atro-

phy of the deltoid and scapular muscles gradually occurs. Pain is a symptom of varying severity. In general, the tendency is toward resolution with more or less impairment of joint motion.

Tenosynovitis may exist and simulate closely chronic synovitis of the shoulder.

Periarthritis of the Shoulder.—Periarthritis of the shoulder-joint has been described[1] as a condition of stiffness not infrequently seen after comparatively slight injuries. Pain accompanies motion beyond a certain limit. Atrophy of the muscles is present, and at times there is some spontaneous pain. The arm may become of comparatively little use. The diagnosis of periarthritis is not based on pathological evidence.[2] In most cases it is of traumatic origin.

Treatment.—In synovitis of the shoulder-joint with any active inflammation, the indication is simply for rest and fixation. These are readily secured by means of a sling and a bandage securing the arm to the side. It is important to mention that in chronic synovitis of the shoulder the weight of the arm dragging upon the joint structures may be a factor in keeping up the pain and irritation. Consequently in the shoulder the use of a supporting sling is necessary in these cases. Compression will be needed if there are swelling and effusion. Traction may be required in the severest cases. Fixation should not be continued longer than there is subacute inflammation, and can be gradually discontinued; first discarding the bandage and retaining the sling, which can be discontinued later. So long as muscular irritability exists, rest is indicated. In these cases an increased arc of motion and diminished sensitiveness will usually follow a few days' rest of the joint, and permanent ankylosis is rendered less likely by the application of timely immobilization.

Fixation should be followed by measures to restore motion and to stimulate the circulation.

The question of the use of forcible passive motion in the convalescent stage does not differ from the same question in other joints. If the stiffness is due to adhesions, manipulation under an anæsthetic, followed by massage, etc., may be of value; but in the majority of light cases gradual passive exercises will suffice. Gentle, graduated, passive motion carried to the verge of being painful, with the use of electricity, is of great advantage in many cases of shoulders stiffened from a slight degree of chronic joint inflammation. If the stiffness above alluded to is the result of the fixation due to muscular spasm, forcible passive motion will be of no use, as the reflex spasm will reappear after the effect of the anæsthetic has passed away, as long as the disease of the joint remains.

[1] Duplay: Arch. Gén. de Méd., Paris. 1872

[2] Jones and Allison: N. Y. and Phila. Med. Journal. 1904.

The treatment of tenosynovitis and periarthritis does not differ essentially from that just described.

Obstetrical paralysis of the shoulder will be considered in a later chapter.

Elbow-Joint.

Chronic synovitis may appear in this, as in other joints, from the usual exciting causes, and presents the same characteristics. What is popularly spoken of as a "*tennis elbow*" is a chronic synovitis and irritability, in which injury to the ligaments, especially to the internal lateral ligament, is a marked feature. It results from the strain of constant tennis-playing or some similar overuse of the elbow, and its treatment does not differ from that of a similar condition in other joints.

Wrist.

Chronic synovitis may occur under the same conditions existing in other joints. *Tenosynovitis* is characterized by pain on the motion of certain fingers, with, perhaps, a sensation of rubbing or creaking in the affected tendons. Tender points are present in the course of these tendons. In the superficial tendons of the wrist, some distention of the synovial tendinous sheath can be seen.

The synovitis of other joints does not require especial mention.

BURSITIS.

Hip.—Inflammation of the bursæ about the hip-joint must be recognized as a condition likely to give rise to symptoms possibly resembling hip disease.[1] This inflammation is most often traumatic, but may be tuberculous. Suppuration and the formation of fistulæ may occur. According to the location of the inflammation the symptoms will differ.

The chief bursæ about the hip are as follows: The subiliac bursæ under the ilio-psoas tendon as it leaves the pelvis; the bursa under the insertion of the tendon of the ilio-psoas. About the trochanter major there are several: one between the fascia lata and the skin; a less constant one between the fascia lata and the trochanter; one under the gluteus medius; one under the tendon of the gluteus minimus; one between the obturator externus and the gemelli; one for the pyriformis; one for the obturator internus. A bursa farther removed from the hip-joint, but one likely to be affected, is one between the gluteus maximus and the tuberosity of the ischium. This affection may be mistaken for hip disease, as there are limitation of motion and limp, and, in the severest cases, suppuration. The diagnosis at times can be es-

[1] Deutsch. Zeit. f. Chir.. December. 1898.—Brackett: Trans. Am. Orth. Assn., 1896.—Lippert: Beitr. z. klin. Chir.. xl.. 503.

tablished only after incision. The treatment consists of the temporary use of crutches and incision in the severer cases.

Bursitis of the Knee.—The various bursæ about the knee may become inflamed and give rise to disability, often of an obscure nature.

Housemaid's Knee.—The most common seat of this affection is in the prepatellar bursa which lies over the patella and part of the ligamentum patellæ. This is not, as a rule, one well-defined sac, but consists of three layers of bursæ more or less well marked and generally in communication with each other and at times with the knee-joint.[1]

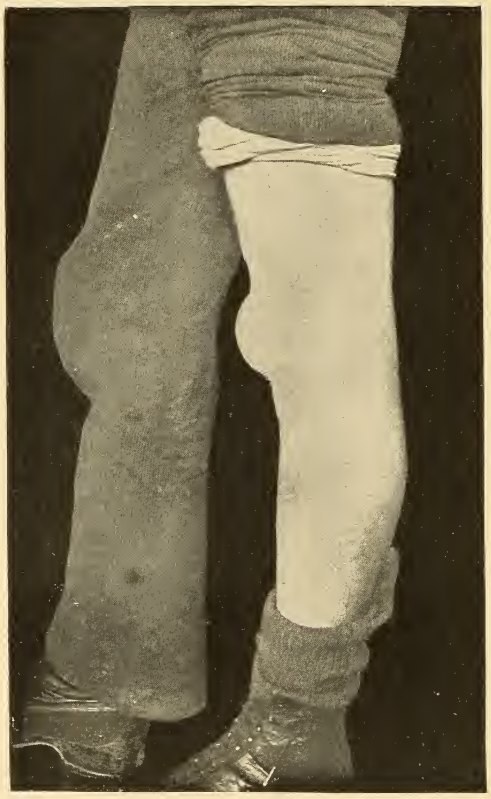


Fig. 203.—Prepatellar Bursitis.

This affection is found chiefly in persons whose occupation leads them to spend much time in kneeling. The acute affection is brought about by over-use of the knee, and is characterized by slight swelling, sensitiveness on pressure, and discomfort in flexing the knee, which is localized at the site of the bursa. Palpation shows a more or less distinct swelling, which lies over the patella and which is rendered more tense by the flexion of the joint. In the acute stage it is likely to be mistaken for synovitis of the knee-joint, especially as the inflammation, if neglected, tends to spread and the swelling may become more diffuse and burrow around the joint; although the chronic enlargement of the bursa is sometimes primary, more often it is the outcome of a series of acute attacks. Fluctuation is clearly present, and the swelling is more sharply localized to the region in front of the patella than in synovitis. In the chronic stage of the affection, heat, sensitiveness, and discomfort are ordinarily absent, except a slight feeling of stiffness in complete flexion of the leg.

For diagnosis, one must depend upon the facts that the swelling is

[1] Bize: Journ. d'Anat. et de Phys., Paris, xxxii., 1896, p. 85.

entirely in front of the patella, that the patella does not float, that the joint is not affected, and that the occupation of the patient in some way has produced continual slight injuries of this region. Although the acute affection shows a tendency toward recovery under rest, the chronic affection does not have this tendency and is likely to continue unabated.

Suppuration occurs in both acute and chronic varieties in a certain proportion of cases. The inflammation of the bursa occasionally occurs in connection with gout, rheumatism, or syphilis.

Treatment.—The acute affection, unless too far advanced, ordinarily yields readily when the limb is placed in the extended position upon a ham splint and the constant irritation of walking is avoided. The application of pressure is of much assistance in allaying the inflammation;[1] a few days or weeks in the milder cases will ordinarily reduce the inflammation. In old cases this treatment has little or no effect. If, however, the bursitis has reached the stage of suppuration, incision affords the only hope of relief.

In chronic bursitis the most satisfactory treatment is to lay the entire bursa open by a crucial incision and dissect out the tough fibrous sac.

Bursitis of the Deep Prepatellar Bursa.—The affection of this bursa presents certain characteristic symptoms often difficult to differentiate from those of synovitis. This bursa lies beneath the ligamentum patellæ next to the tibia.[2]

The inflammation of this bursa is described under various names, one of them being *pseudarthrose du genou.*[3]

The peculiar symptoms of this affection are pain in complete extension of the leg, referred to the tubercle of the tibia; pain and tenderness, referred to the patella tendon; apparent enlargement of the tubercle of the tibia, and bulging at the sides of the ligamentum patellæ. The affection[4] may be mistaken for inflammation of the superficial pretibial bursa or for the inflammation of abnormal bursæ in this neighborhood. Careful examination will usually differentiate it from synovitis of the knee-joint. Tuberculosis of this bursa may occur.

The treatment does not differ from that of housemaid's knee except that bursitis of the deep pretibial bursa is more obstinate.

The inflammation of other bursæ about the knee-joint presents no peculiar symptoms, and the existence of the affection is made evident by the presence of a fluctuating swelling at the site of a bursa.

[1] Hoffmann: Am. Journ. of Orth. Surgery, vol. ii., 2.

[2] Lovett: Boston City Hosp. Reports, 8th series, p. 345.

[3] Dubreuil: Annales d'Orth., Paris, September, 1890.—"Traité de Path. ext." (Follin), iii., 19.—Pitha and Billroth: "Chirurgie," iv., 1, Heft 2, p. 242.

[4] Osgood: Boston Med. and Surg. Journ., January 29th, 1903 (with literature). —Lovett: Phila. Med. Journ., January 6th, 1900.

Bursitis[1] **of the Shoulder.**—Although this affection may simulate synovitis, the limitation of motion induced by it is only in certain directions, and tenderness and swelling are chiefly confined to the affected structures. The bursæ most frequently affected are those of the subscapular, the deltoid, and the coracoid regions. The disease is generally tuberculous.

HABITUAL OR RECURRENT DISLOCATIONS.

Patella.—Dislocation of the patella or slipping patella is likely to occur either spontaneously or for very slight cause in certain young girls with lax muscular fibre and a feeble development, and boys are only exceptionally attacked.[2]

In consequence of some slight twist of the leg, as in dancing, rising from a chair, going upstairs, or some similar motion, an excruciating pain is felt in the knee, and the person either falls in consequence of faintness or finds herself unable to use the leg. Very often the patient herself hears a cracking sound when the dislocation occurs. The patella is found almost always dislocated outwardly, sometimes twisted so that its lateral edge rests against the front of the femur (vertical luxation of Malgaigne). The reduction of the dislocation is very simple and is very soon learned by the patients themselves. The leg is fully extended and the patella gently pressed back into place until it assumes its proper place with a click, or often it slips back of its own accord when the leg is straightened. An attack of synovitis follows, as in the case of loose bodies, but the joint soon acquires a tolerance so that each succeeding attack of synovitis becomes less.

The cause of the affection seems to be, in most cases, the lack of tonicity in the extensor muscles of the thigh, or the elongation of the ligamentum patellæ, but very commonly the former.

After many attacks of dislocation the patients complain of a certain sense of insecurity in walking, which in severe cases may amount to a distressing disability, limiting the patient's ability to walk or engage in active occupation.

Mechanical Treatment.—If an elastic knee-cap is split in front and furnished with lacings or straps, and if felt pads are sewed upon the sides of the cap at such places as would exert pressure upon the sides of the patella, an arrangement is furnished which, when properly adjusted, will give a serviceable support in lighter cases, allowing motion at the knee.

The following steel appliance will be found of service: It consists of two uprights, hinged at the knee, extending from the middle of the calf to the middle of the thigh on each side of the limb, and connected

[1] Blauvelt: Beitr. z. klin. Chir., xxii.—Ehrhardt: Arch. f. klin. Chir., 1900, xl.
[2] Bade: Zeit. f. orth. Chir., xi., 3.

with cross-pieces above and below. To these are attached at the level of the middle of the patella semilunar plates, which are of such a shape and are bent in such a way as to press upon the sides of the patella. They are covered with padding and leather. If leather straps pass diagonally from the uprights to buttons upon the top and bottom of these plates, an adequate amount of side pressure will be secured. Two straps from underneath the knee prevent the apparatus from falling forward, and the straps mentioned prevent the apparatus from slipping backward. It is essential that this appliance should not remain in a

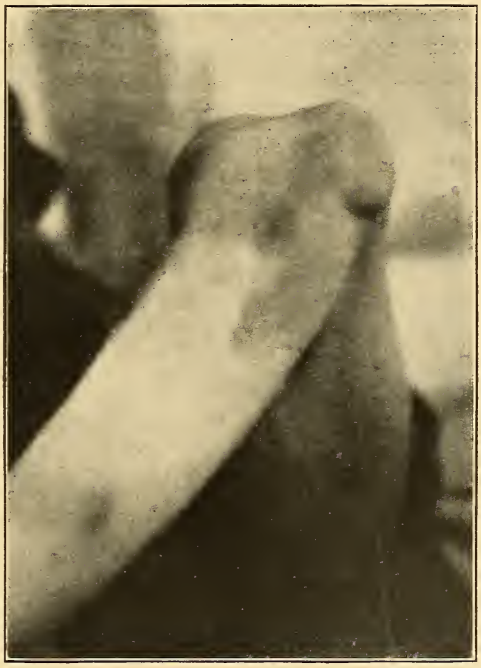


FIG. 204.—Dislocation of Patella.

bent position, as the pressure at the sides of the patella would in that case be diminished. To prevent this a spring is furnished, connecting the upper portion of the upright with the lower portion, with sufficient strength to force the appliance into a straight position, but allowing bending of the knee by muscular effort.

Some such retentive apparatus, along with the use of massage and electricity, may effect a cure, especially in rapidly growing girls.

Operative Treatment.—In resistant cases, or those unable to follow out proper mechanical treatment, operation will be required.[1]

This consists in the removal of an elliptical piece of the front of the

[1] Bade: Zeit. f. Orth. Chir., xi., 3, 451 (with bibliography).

capsule of the joint internal to the extensor tendon and a stitching together of the edges of the opening, thereby tightening the inner part of the capsule.[1]

In resistant cases a vertical incision outside of the patellar tendon must also be made to allow the patella to be pulled into place by the tightening of the capsule on the inner side.

The tubercle of the tibia may be transplanted [2] farther in on the tibia, or the patella tendon may be split longitudinally and the inner half carried under the outer and attached to the tibia outside of the tubercle.[3]

Habitual or recurrent dislocation of the shoulder becomes at times an affection requiring orthopedic treatment.

The causes of the condition may be formulated as follows: [4] 1. Laxity of the capsule of the joint. 2. Partial fracture of the head of the humerus. 3. Partial fracture of the glenoid cavity. 4. Tearing away of muscular insertions and rupture of tendons. 5. Abnormality in the shape of the head of the humerus not demonstrably due to fracture.

It would seem as if in certain instances the cause of the recurrence of the dislocation was insufficient immobilization of the arm after a primary dislocation.

The atrophy of certain muscles seems to be characteristic in these cases in a series observed by one of the writers.[5] These are the coracobrachialis, triceps, deltoid, especially the posterior part, supra- and infraspinatus, rhomboids, levator anguli scapulæ, and latissimus dorsi. Limitation of motion is not so much due to pain or to fear of displacement as apparently to some lesion in the joint mechanism. It should be noted that a large proportion of epileptics are found in all reported cases. Reduction is as a rule easy, and inflammatory reaction in the joint is notably slight or even wholly absent after reduction.

Prognosis.—In a shoulder-joint in which a dislocation has once or twice occurred from insufficient cause, it is not likely that the liability will become less frequent as time advances if no treatment is undertaken. As a rule, the dislocations will occur with greater frequency and from slighter causes as time progresses.

Treatment.—The methods of treatment are:

By apparatus; by massage and exercises alone; by temporary fixation and massage; by operation.

The use of apparatus confining the arm to the side is to be con-

[1] N. Y. Med. Record, April 20th, 1895.—Trans. Am. Orth. Assn., vol. viii., p. 227.—*Ibid.*, vol. viii., p. 237.

[2] Annals of Surg., 1899.

[3] Goldthwaite: Am. Journ. Orth. Surgery, vol. i., No. 3.

[4] Stimson: "Dislocations," p. 265, quoting also Gurlt, "Path. Anat. der Gelenkkrankheiten," p. 250.—Cushing: Med.-Chir. Trans., 1837, p. 336.

[5] Burrell and Lovett: Am. Jour. Med. Sciences, August, 1897.

demned. It weakens the muscles by causing their disuse. It is uncomfortable and partially disabling, and its use can be considered justifiable only temporarily or under exceptional conditions.

An apparatus used by one of the writers seems as little objectionable as any. It consists of a leather shoulder cap embracing the arm, strengthened by two steel strips, one horizontal strip running from before backward and fitting the outer contour of the shoulder. The other, a longitudinal strip, runs from the base of the neck to the middle of the outside of the arm. There is a joint connecting the two steel strips opposite the shoulder, allowing antero-posterior motion in the shoulder. The shoulder cap is fastened in place by a chest band; the apparatus prevents abduction of the arm to any degree likely to produce dislocation.

Fixation for some time is called for when a second dislocation has occurred from slight cause. The arm is lifted by applying a sling, which supports the forearm and point of the elbow. The arm is held to the side by a swathe, thus preventing all motions of the joint. This removes as much weight as possible from the joint capsule.

Such cases have been operated upon successfully by reefing the anterior part of the capsule of the joint through an anterior incision.[1]

Symphysis Pubis.—*Relaxation* of the joint in the symphysis pubis occurs at times during pregnancy, so that walking becomes difficult or impossible. After delivery the abnormal condition may disappear or may persist as a source of disability. It is best treated by a leather or plaster jacket fitting tightly over the sacrum and ilia, along with as much limitation of walking as may be necessary.

TUMORS OF THE BONES AND JOINTS.

Primary tumors of bone belong to the group of connective-tissue tumors. The periosteum and bone marrow form the matrix for their development. These tumors correspond to the various types of connective tissue, fibrous, mucoid, cartilaginous, and osseous. Among primary tumors are to be classed sarcomata. Secondary tumors of any kind may occur, among the latter being carcinoma. Angioma, hæmatoma, echinococcus cyst, and aneurism must be mentioned as other possibilities.

Exostoses.—Apart from the changes of arthritis deformans, there sometimes occur exostoses about the articular ends of the bones, which are very rarely large enough to impede the motion of the joints; at other times they are troublesome by involving tendons in their growth.

[1] Cent. f. Chir., 1883, p. 28; Beilage z. Cent. f. Chir., 1882, p. 73, and 1886, p. 90; Deutsch. Zeit. für Chir., 1880, xiii., p. 167.—Pitha and Billroth, ii., p. 652.—"Aseptic and Antiseptic Surgery," p. 8.—Bull. de l'Acad. de Méd., 1894, p. 334.—Burrell and Lovett: Am. Jour. Med. Sciences, August, 1897.

Cartilaginous exostoses in the neighborhood of the joints have occasionally a capsule overlying the layer of cartilage corresponding in structure to synovial membrane. This condition is spoken of as a bursate exostosis.

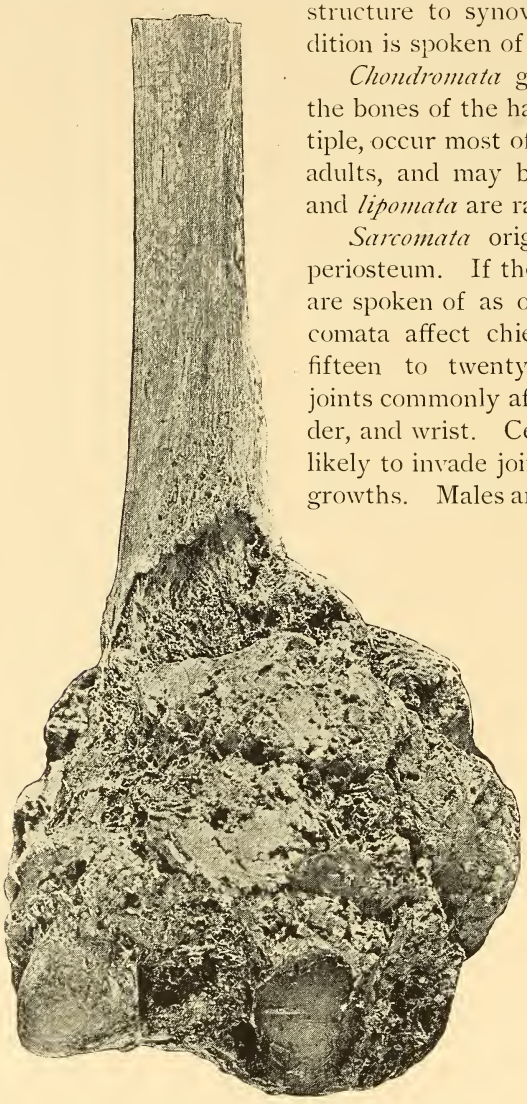


FIG. 203.—Tumor of Femur Involving Knee.

Chondromata grow most frequently from the bones of the hand. They are often multiple, occur most often in children and young adults, and may be congenital. *Myxomata* and *lipomata* are rare in the bones.

Sarcomata originate in the marrow or periosteum. If they contain bony tissue they are spoken of as osteosarcomata. Joint sarcomata affect chiefly young subjects from fifteen to twenty-five years old, and the joints commonly affected are the knee, shoulder, and wrist. Central sarcomata are more likely to invade joints than are the periosteal growths. Males are slightly more liable than females to be affected.

Carcinomata of bone may occur secondarily from extension or metastasis. They occur in circumscribed nodes or as a diffuse infiltration. The latter form is usually accompanied by proliferation of the periosteum and absorption of the substance of the bone. This is at times replaced by soft new bone, and a condition may be present resembling locally osteomalacia and known as carcinomatous osteomalacia.

With this form, as with primary new growths, spontaneous fracture may occur.

Malignant Disease of the Spine.

Sarcoma and carcinoma of the vertebral column are occasionally met. Carcinoma has been noted following similar disease of the breast

and testicle, and less frequently of the stomach. The occurrence may be from direct extension or from general infection.

The disease usually begins as an infiltration of the spongy tissue of the vertebral bodies, which is gradually replaced by the malignant growth. There may be but little change in the appearance of the bodies, but these will be found converted into a soft, friable mass. Destruction of the bone substance with deformity may occur.

The most frequent site of malignant disease is in the lumbar region, and the next commonest location is in the dorsal vertebræ.

The disease may pursue an insidious course, and not be suspected until found at the autopsy. This, however, is rare, and a serious affec-

FIG. 206.—Sarcoma of Spine.

tion is usually evident, even though no diagnosis is made. The symptoms are similar to those of Pott's disease, pain being very prominent, with frequently paralysis. Both are the result of the encroachment of the growth on the spinal nerves and cord. The location of the pain will depend on the site of the diseased vertebræ, and it is usually increased by pressure and motion, and it extends in the arms, trunk, or legs.[1] The paralysis usually follows a disturbance in sensation, and is due to compression from extension of the disease or from involvement of the meninges. It may be partial or complete, and as a rule does not occur suddenly. Tenderness over the spine is an uncertain sign, and probably has no diagnostic importance. When deformity occurs it will

[1] Edes: Bost. Med. and Surg. Jour., June 17th, 1886, 559.

be found to present a more rounded prominence than is usually seen in Pott's disease. Hemorrhage from the bowels or hæmaturia has been observed.

When following malignant disease elsewhere, which can be recognized, the diagnosis should present no special difficulty, but in other instances it is usually hard or even impossible. It should be distinguished from aneurism of the aorta, cervical pachymeningitis, and Pott's disease.

The prognosis needs no comment; a fatal end is only a matter of time.

Malignant Disease of the Hip.

The variety of tumor which most often affects the head of the femur in young children is a round-cell sarcoma of the periosteum. But the epiphysis is rarely the seat of the tumor. In seventy cases of sarcoma of the femur, analyzed by Gross, there were only two cases in which the upper epiphysis was affected.

The early symptoms in cases in which the head of the femur is not primarily involved are very slight, and consist chiefly of a swelling which is painless and not fluctuating; limp and slight restriction of motion may be present. Soon, however, it becomes evident that the enlargement is predominating over all the other symptoms and the swelling progressively increases, suggesting perhaps hip abscess. Fluctuation, however, is absent and the swelling embraces the whole circumference of the limb. There is an enlargement of the superficial vessels and the swelling later becomes enormous. The patient becomes emaciated and wastes away. The affection may be very painful or again it may be attended with very little suffering. Amputation at the hip-joint, if performed sufficiently early, is the only remedy.

SYPHILIS.

Acquired syphilis may present joint manifestations.

Arthralgia without objective symptoms may occur early in the secondary stage. Simple serous synovitis, associated with pain, redness, and swelling, may accompany the secondary symptoms. This condition may pass on to a chronic hydrops. In the tertiary stage chronic serous synovitis may be present.

These and other processes may be the result of gummata of the ends of the bones or in the periosteum or situated about the joints, not necessarily in any intimate connection.

Gummatous ostitis is a cause of secondary affections of the joints when situated in their neighborhood. On section the bone shows, most often in the periphery, a yellowish-gray focus of disease, in appearance strikingly like the early stage of focal tuberculosis. But from this lat-

ter it may be distinguished by the absence of any surrounding hyperæmia or infiltration, which goes with tuberculous disease. Often, of course, these gummata exist along with much synovitis of a characteristic type, and a much thickened and diseased periosteum. Gummata in the periosteum appear as elastic swellings, rich in fluid, poor in cell elements; later they degenerate to material like pus, and by fatty degeneration and absorption, to a cheese-like substance and scar tissue, and finally only a thickening remains.

Secondarily to these periosteal and bone lesions come the capsular and synovial thickening and the cartilage degeneration.[1]

Hereditary syphilis is proportionately more often attended by joint complications than is acquired syphilis.[2]

The most characteristic form of joint disease in hereditary syphilis in children is the *osteochondritis* of Parrot. This consists in a broaden-

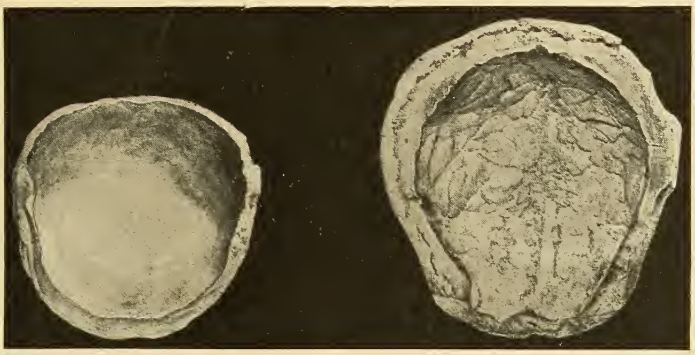


FIG. 207. FIG. 208.

FIG. 207.—Ostitis Syphilitica. FIG. 208.—Hyperostosis. (R. H. Fitz.)

ing of the cartilaginous layer of the epiphysis next to the diaphysis, with irregularity of the zone of ossification. At the same time there occur thickening of the epiphysis and a growth of granulation tissue, sometimes breaking down in the medullary cavity. As a result of this process, separation of the epiphysis may occur spontaneously or as the result of some trauma. Secondary synovitis is likely to accompany this process. This may be of any character and is often purulent, and the cartilage may degenerate and soften. Suppuration in general is less rare in hereditary than in acquired syphilis.

The clinical symptoms of this osteochondritis are thickening of bone at the epiphyseal line, tenderness, and joint inflammation, secondarily with lameness and even uselessness of the limb for a time. It may

[1] N. Y. Med. Jour , February 4th, 1899.

[2] Berl. klin. Woch., 1884, 442.—Lancet, 1886, i., 391.—Deutsch. Chir., Lief. 66, p. 294.

involve several joints. The affection is sometimes spoken of as syphilitic pseudoparalysis of infants.

Later hereditary syphilis may show a somewhat similar affection, due to overgrowth of the epiphysis and spoken of as "chronic osteoarthropathy of hereditary syphilis" or "false tumor albus." The thickened and deformed epiphyses form a mass which appears as a spindle-shaped swelling (most often at the knee). There is typically no muscular spasm, although marked atrophy of the muscles is present. Pain is generally absent, although rarely there may be some tenderness and local heat. What inflammation of the joint is present is secondary and not characteristic. It is favorably affected by the usual treatment for syphilis.[1]

Syphilis of the Spine.—Syphilitic destruction of the bodies of the vertebræ must be regarded as possible and not unlikely, but the recorded cases of this sort are not in general satisfactory as proving pathologically that such a condition has existed. The presence of syphilis in a patient with a knuckle in the back does not prove that tuberculosis is absent or that the vertebral destruction is of a syphilitic character.

The occurrence of gummata in the vertebræ or near them in such position as to cause pressure on the cord must be admitted, also the syphilitic origin of certain vertebral exostoses.[2]

The diagnosis of syphilitic spondylitis in most cases has rested on the slenderest clinical evidence, which cannot be accepted. The case reported by Joachimsthal,[3] where a cervical deformity disappeared under antisyphilitic treatment, is of interest in this connection. Under these circumstances nothing can be said of the clinical course of the affection.

GOUT.

The joint affection, which is the manifestation of the constitutional malady known as gout, ordinarily begins as an acute attack, and is followed by a chronic inflammatory process, increased by constant exacerbations. The synovial membrane first presents the appearances of acute inflammation; the cartilage also shows a tendency to inflammatory degeneration and erosion, and on its free surface and in its tissue, as well as in its capsule and periarticular structures, there appears a deposit of acicular crystals of urate of soda, which localized deposits

[1] Borchard: Deutsch. Zeit. f. Chir., lxi., 110.—Hippell: Münch. med. Woch., xxxi., 1903.—Palier: Am. Med., July 18th, 1902.—Dunn and Robinson: Lancet, August 1st, 1903.

[2] Charcot: Comptes rendus de la Soc. de Biol., 1865, 28.—v. Bechterew: Neurol. Centralbl., 1893, 313.—Föderl und Peham: Deutsch. Zeit. f. Chir., xlv.—Amidon: N. Y. Med. Jour., 1887, 225.

[3] Zeitsch. f. orth. Chir., xi., 1, 200.

are known as "tophi." The marginal growths are true exostoses and not, as in arthritis deformans, covered by proliferating cartilage. There is a permanent thickening of the synovial membrane. There is but little tendency to suppuration, unless the calcareous deposits ulcerate through the skin by pressure and so open the periarticular tissue. The common seat of the affection is the metatarsophalangeal joint of the great toe (podagra). The joints of the hands, and the knee- and elbow-joints are also often affected.

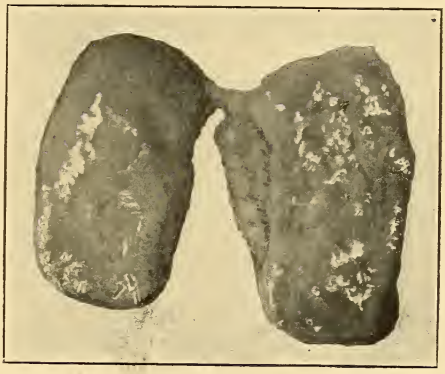


FIG. 209.—Knee-joint Surfaces in Gout, Showing Deposits.

OSTITIS DEFORMANS

Paget's disease—Osteomalacia chronica deformans hypertrophica—Paget'sche Krankheit.

These names designate a deformity affecting the long bones, chiefly

FIG. 210.—Photograph and Radiograph of Case of Gout, Showing the Deposits.

in their diaphyses, and causing them to bend. It most frequently attacks the lower extremities first, also involving the spine and the skull. The upper extremities are at times curved. The process consists of a thickening and curving of the affected bones, the bone hyper-

trophying as a whole and its curves increasing, while the external surface is roughened. In some cases the enlargement takes place by the expansion of the cortex; in other cases the spongy part of the bone is extended. The skull shows marked thickening and enlargement, sometimes to four or five times its normal thickness, and its surface is rough and uneven.

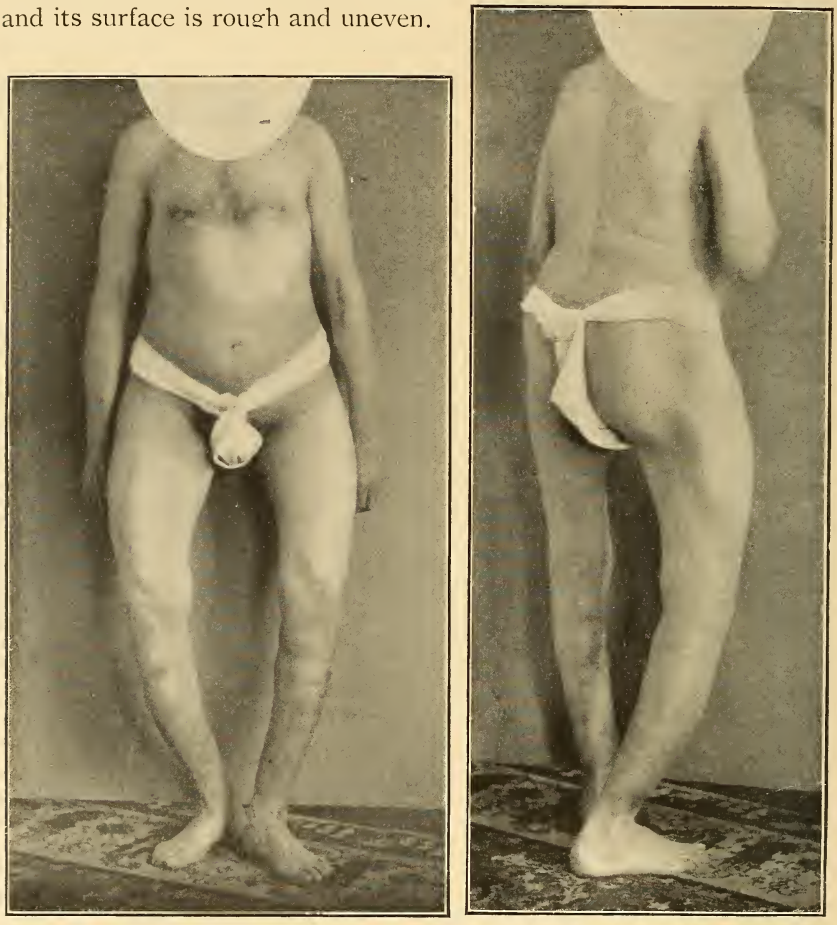


FIG. 211.—Ostitis Deformans. Male, age fifty-four. First definite signs seven years before photograph. Present involvement most marked in cranium, clavicles, right ulna, left radius, pelvis, tibiæ, and fibiæ. (R. B. Osgood.)

Microscopic examination shows appearances of absorption and new formation. The first is shown by the formation of Howship's lacunæ, and where one finds the formation of new bone it is very poor in lime salts. Later deposit of lime salts may occur in this tissue, forming thick sclerotic islands in the osteoid tissue. The marrow and vascular spaces are increased in extent and the fatty part of the marrow tends to become fibrous. The proportion of mineral salts in the bones is diminished.

Etiology.—In the matter of etiology nothing definite has been established. The disease attacks men more frequently than women, as was found in the analysis of twenty-five personal cases by R. B. Osgood and W. A. Locke, of Boston.[1] They also found that the disease began at an earlier period of life than was previously supposed, the average of twenty-one cases showing the period of onset to be at the age of forty-three to forty-four years. It is significant that in the majority of their cases, the disease was associated with marked arteriosclerosis. In five other cases there were manifestations of arthritis deformans. The relation of the two diseases is obscure, and Richard asserts that pathologically they are identical.[2] This point of view cannot yet be regarded as established.

FIG. 272.—Lower Leg, Ostitis Deformans. Bowing and lamellar thickening of tibia and fibula. Areas of rarefication or true cavity formation with apparent periosteal overgrowth and cortical increase. Coarse trabeculation and partial obliteration of medullary cavity. Marked arteriosclerosis. (R. B. Osgood.)

Symptoms.—The affection is generally ushered in by a long period of pain described as "rheumatic" and by headaches.[3] Some cases are, however, practically painless. In cases of involvement of the skull neuralgia from pressure may be present, but the reflexes and electrical reactions remain normal. The general condition of the patient is often not seriously affected. The attitude is characteristic, the patient

[1] Paper not as yet published.

[2] "Hdbch. der orth. Chir.," Joachimsthal. Jena, 1904, p. 81.

[3] Wallenberg: Zeitsch. f. orth. Chir., xiii., 1.

stands with the legs bowed and the spine bent in a gradual backward curve, the body is carried forward bent at the hips, and the skull is greatly enlarged. The gait becomes clumsy and stiff, the head drops tow-

FIG. 213.—Ostitis Deformans. Marked involvement of left radius and right ulna. Characteristic coarse trabeculation and lamellar thickening with irregular periosteal outline. Medullary cavity obscured or obliterated. Beginning process in proximal phalanx of left thumb and right os magnum. Arteriosclerosis of many vessels. (R. B. Osgood.)

ard the chest, and the shoulders are round and stooping. The spine loses its flexibility and becomes more or less rigid. Scoliosis may occur in the spine of a moderate degree. The body is shortened in the erect position, and the backward curve of the spine and the attitude

resemble that of spondylitis deformans. In ostitis deformans, however, the joints are as a rule exempt, and the diagnostic symptoms are the occurrence of bow-legs beginning in the latter half of life, the bending backward of the spine, the hypertrophy of the bones, and especially the great thickening of the skull. Fractures occur rarely, and in the cases observed (Smith, Taylor, Kedder, Bradford) they united readily.

Prognosis.—The prognosis of the affection as far as life goes is not

FIG. 214.—Charcot's Disease of Right Knee-joint. (Weigel.)

unfavorable, and death generally occurs from intercurrent affections. No satisfactory treatment has been formulated. Protective apparatus in the severer deformities may be necessary, but they increase muscular weakness and are to be avoided if possible.

PATHOLOGICAL CONDITIONS OF THE NERVOUS SYSTEM.

Charcot's joint disease, spinal or neuropathic arthropathy, neural arthropathy, tabetic arthropathy, etc.

A destructive form of joint disease may be associated with locomotor ataxia, syringomyelia, Pott's disease, acute myelitis, injuries of the

peripheral nerves, cerebral apoplexy, tumors of the cord, crushing of the spinal cord, progressive muscular atrophy, and anterior poliomyelitis.

The pathological process is in many respects similar to that in arthritis deformans, except that the destructive process is more rapid and the formative activity less. The cartilage disintegrates, the ends of the bones are exposed and may be rapidly worn away, the synovial membrane and ligaments thicken and ulcerate. This process may result in spontaneous luxation in severe cases. Synovial effusion may be present, and suppuration may occur. Hypertrophy of the epiphyses may take place as well as the formation of osteophytes, but atrophic changes predominate. The essential character of the affection is the rapid melting away of cartilage and bones, and the joint changes may be present at an early stage of the nervous disorder.

The affection is most often monarticular, and although adults are generally affected, cases have been recorded as early as the sixth year. The joints are affected in approximately the following order of frequency: knee, hip, shoulder, tarsus, elbow, ankle, wrist, jaw, and spine.

Swelling, effusion, disability, and sometimes pain are the first signs of the joint involvement. Spontaneous arrest of the process may occur, and ankylosis may rarely result. More commonly, however, the joint is disorganized to the point of luxation. The diagnosis is often difficult, especially in the early stages.

The treatment does not differ essentially from that of inflamed joints in general. The nervous lesion must be treated, and although excision of the joint has been successfully done under these conditions, local operative measures are not, as a rule, to be advised. In cases in which syphilitic history is present, mercury or iodide of potassium should be given.

Arthropathy of the vertebral column has been rarely observed in tabes. It is manifested by a deformed position of the column, shown by scoliosis and backward bending of the spine.[1] Partial relief may be afforded by fixation.

Arthropathy of the Hip.—In frequency of attack the hip comes next to the knee, which among the large joints is the one most often affected. As in most other instances, Charcot's disease of the hip simulates very closely arthritis deformans of the ordinary type. The changes in the joint are, however, much more acute and extensive than those with which we are familiar in arthritis deformans. Synovial effusion is a more prominent symptom, sometimes reaching the stage of a large fluctuating tumor which presents itself at the front and the back of

[1] Spiller: Am. Medicine, November 1st, 1902, p. 701 (with bibliography).—Graetzer: Deutsch. med. Woch., December 24th, 1903.

the joint, with a wearing away of the head of the bone. The trochanter ascends and a state of affairs similar to the condition found in late hip disease is presented. In the matter of diagnosis, of course one depends upon the coexistence of symptoms of spinal-cord disease. As to treatment, little can be accomplished; in cases in which swelling is excessive, aspiration of the joint sac may give temporary relief. Rest is indicated for the joint, with traction if it gives relief.

FIG. 215. — Disease of Right Knee-joint of Six Years' Duration Due to Hæmophilia, Showing Swelling and Flexion Deformity.

HÆMOPHILIA.

Hæmophilia is accompanied at times by characteristic joint lesions, which in their clinical resemblance to tuberculosis are worthy of notice.[1] The knee is the joint most frequently affected. Like other manifestations of this diathesis, joint affections occur most often in male children or young adults, decreasing in frequency with increasing age. The hemorrhage may be intraarticular or periarticular. After repeated acute attacks of hemorrhage into the joint, chronic joint changes are likely to ensue. There is an overgrowth of brown-stained synovial tufts. The cartilage may degenerate, and sharp-bordered defects in it are frequently found. Adhesions, contractions of the capsule, and bony displacements may occur. Erosion of the ends of the bones may take place along with a proliferation at the edges not unlike arthritis deformans. A brown staining of all the joint structures, except the cartilage, is described as characteristic.

Rheumatic pains are a common clinical accompaniment of the affection, and its character is essentially chronic. Swelling and muscular spasm are present during attacks of irritation, and the diagnosis from tuberculosis is to be made more from the history than from any characteristic features.[2]

[1] Am. Medicine, March 21st. 1903, editorial.—Carless (with analysis of 253 reported cases): Practitioner. 1903. lxx., 85.

[2] Linser: Bruns' Beitr. zur klin. Ch., Bd. xvii., 105.—Volkmann's Samml. klin. Vorträge (Transl. Med. Surg. Reporter. lxvi., No. 26. p. 999).—Gocht: Münch. med. Woch., 1899. February 21st. 271.

General treatment offers but little hope, although the use of gelatin by mouth, in doses of six or more ounces daily, has been found of use.[1]

FIG. 216.—Clubbing of Fingers in Secondary Osteo-arthropathy.

Protection to the diseased joints is of more use than any other one measure, but the prognosis as to recovery is doubtful at best. Aspiration with a small needle may be safely done for purposes of diagnosis.[2]

FIG. 217.—Secondary Osteo-arthropathy Due to Pott's Disease, Showing Enlargement of Liver and Spleen.

Fatal hemorrhages have occurred as the result of operation on these supposedly tuberculous joints.

[1] Hesse: Ther. der Gegenwart, September, 1902; Practitioner, 1903, lxx., 85.

[2] For normal processes of absorption of blood in joints see Jaffé: Langenbeck's Archiv, Bd. liv., Hft. 1.

SCURVY.

Joint affections in infantile scurvy are not uncommon, and simulate closely epiphysitis. The enlargement may be confined to one of the bones forming an articulation. The thickening is due to periarticular or rather subperiosteal hemorrhage, and the joint itself is not usually affected, though hemorrhage may occur. Such joints yield readily to the usual treatment of infantile scurvy. Such apparent inflammation of joints occurring in scurvy is regarded as being more often due to extraarticular than to intraarticular lesions, subperiosteal hemorrhage being the most frequent lesion. In 379 cases of scurvy investigated by the American Pediatric Society [1] there were swellings in, or more often about, the joints in 165. These were distributed as follows: Knee, 73; ankle, 28; wrist, 12; hip, 6; shoulder, 5; elbow, 3; hand, 1.

In 40 analyzed with regard to the coexistence of rickets, in 45 per cent there were symptoms of rickets, while in 55 per cent rickets was said to be definitely absent.

SECONDARY HYPERTROPHIC OSTEO-ARTHROPATHY.

This is the name given to a condition occurring sometimes in connection with chronic pulmonary disease, in which the fingers are clubbed and stiffened, the shafts of the bones are thickened, and the spine is bent forward in a kyphosis. It occurs sometimes in connection with Pott's disease. The relation of the affection to acromegaly and osteomalacia is not clear.

In this condition the joints are occasionally swollen and painful with effusion. The changes as shown by autopsy [2] are synovitis and thinning of the articular cartilages even to the extent of exposing the bone. Along with this is associated periostitis and some sclerosis of bone which may involve the shaft.

GROWING PAINS.

A joint affection incident to growth has been described by Bouilly, and has long been known but unclassified by practitioners, and popularly considered to be incident to growth—"growing pains." There is slight pain chiefly in the juxtaepiphyseal region, most commonly near the lower epiphysis of the femur. This pain is brought on by fatigue, strains, or exposure. In the lightest cases the symptoms pass away in a few hours. In severer forms they may last for several days, and the pain may be accompanied by slight fever. In the severest form the

[1] Boston Med. and Surg. Jour., vol. cxxxviii., 607.

[2] Lefebre: Thèse de Paris, 1891.—Ranzier: Rev. de Méd., 1891, p. 30.—Whitman: Pediatrics, 1899, vii., Nos. 4 and 5 (with bibliography).—Janeway: Am. Journ. Med. Sci., October, 1903 (with bibliography).

affection may continue for months. There may be slight effusion in the joints, but recovery eventually takes place. It may occur during the ages between five and twenty-one.

A great amount of harm is done in referring to this class the pains of beginning chronic joint disease. Growing pains proper are neither severe nor permanent.

Analogous to this may be mentioned what has been termed by French writers maladie de la croissance—which is in reality a hyperæmia and sensitiveness of the epiphysis in adolescents—analogous to what is seen occasionally in rickets.

ACTINOMYCOSIS.

Actinomycosis is a specific infectious disease occasionally attacking the bone secondarily, and is caused by the streptothrix actinomycotica (ray fungus). The process in the bone is a destructive one.

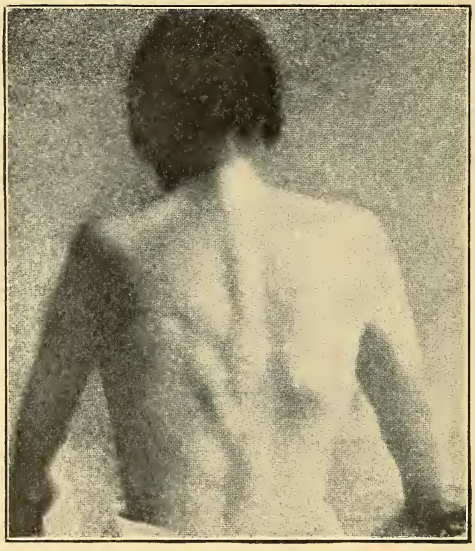


FIG. 218.—Myositis Ossificans. (Michelson.)

The spinal column, ribs, and sternum may be attacked, but the maxilla is the bone most frequently affected, and the whole affection is to be regarded as one attacking the soft parts, the involvement of bone being only secondary and incidental. The source of the infection is through the gastrointestinal or respiratory tract, and the persons commonly affected are those who live in the country and handle grain.[1]

Actinomycosis of the spine is rare, but few cases having been re-

[1] Ruhrah: Annals of Surgery, vol. xxx., p. 417.—Von Braez: Annals of Surgery, vol. xxxvii., p. 337.—Acland: Lancet, 1886, p. 973.

ported. It may be destructive, resembling Pott's disease. In a case seen by one of the writers, in which the upper dorsal region was affected, there was an extensive induration of the neck and shoulders and the skin was riddled by sinuses. The constitutional disturbance was very marked, as shown by anæmia and prostration. The early symptoms had been similar to those of Pott's disease, and there was flattening of the back of the neck. The diagnosis was made by microscopic examination of the discharge from the sinuses.

The treatment consists in the administration of iodide of potassium.

In the writers' case progressive improvement in symptoms followed the use of this drug.

Echinococcus cysts of the spine have been observed.[1]

MYOSITIS OSSIFICANS.

This affection in its symptoms is closely enough allied to those caused by certain joint diseases to require mention. The pathology of

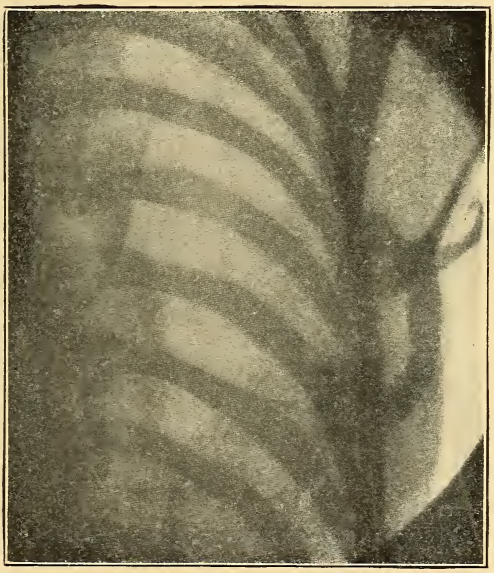


FIG. 219.—Radiograph of Same Case Showing Irregular Deposits of Bone. (Michelson.)

the disease consists of the formation of bone tissue in the connective tissue surrounding the muscles. This is of the periosteal type and occurs in plates or irregular shapes. The affection is one largely affecting children and its cause is unknown. Trauma is a cause of many cases, and at times the disease is progressive, attacking one muscle after another. The affection is most commonly found in the forearm, leg, or thigh, but any muscle may be involved.

[1] Friedberg: Schmidt's Jahrb., 1897.—Bruns' Beitr., xi., 1894.

The affection is manifested clinically by the appearance of tumors involving the muscle, which may or may not be painful. Fever may be present or absent. The muscles involved are stiffened and may become useless, while at other times but little inconvenience is felt.

No satisfactory treatment has been formulated and no measure has been found to control the disease. The tumors may be excised.[1]

ANKYLOSIS.

Ankylosis is the name used to characterize the persistent stiffness of a joint. This may be "complete" when all motion is lost, or "partial" or "incomplete" when some part of the normal motion remains. It is also classified as "bony" or "fibrous" ankylosis, according to the character of the tissue binding together the joint surfaces. False ankylosis, pseudo-ankylosis, etc., are terms used to designate a condition of joint stiffness in which the restriction of joint motion is due, not to destruction of the joint surfaces, but to other causes, such, for example, as the development of osteophytes and the like around the edges of the joint occurring in arthritis deformans, the contraction of the joint capsule, etc.

The name ankylosis should not be applied to the stiffness of joints due to the tonic muscular spasm of acute or chronic joint disease. This disappears under anæsthesia, whereas ankylosis is not affected by it.

The pathology of ankylosis is the pathology of the affections which cause it. It represents in general the end result, the cicatrix, of an acute or chronic joint inflammation or of a more or less severe trauma. True ankylosis in all cases consists of the formation of fibrous tissue connecting the ends of the joint, which later is apt to undergo bony transformation. The cartilage, if not originally destroyed by the disease, degenerates from disuse, and in the severer cases the entire ends of the bones are connected by fibrous bands, and later by a solid mass of bone. In such cases the cortical parts of the ends of the bones forming the joint may be absorbed and the medullary cavity may extend uninterrupted from the leg to the thigh, for example. In such cases the joint is wholly obliterated, and the leg and thigh form one continuous bone.

Stiffness of joints may also result from adhesions between the synovial membrane, from contraction of the capsule and ligaments, from adhesions between the tendons and their sheaths, from periarticular cicatrices due to abscesses and trauma, from marginal ecchondroses and exostoses, from the ensheathing formation of new bone, the alteration of joint surfaces in arthritis deformans, and from fractures and dislocations.

[1] Binine: Annals of Surgery, 1903 (report of 86 cases).—C. Rothschild: Beitr. z. klin. Chir., xxviii., 1.—Michelson: Zeitsch. f. orth. Chir., xii., 3 (with bibliography).

The causes of acquired ankylosis are therefore to be found in acute or chronic joint inflammation, in the ankylosing form of arthritis deformans, in fractures involving the joints, in trauma of various kinds, and in periarticular suppuration and trauma. The fixation of normal joints for any reasonable time does not cause true ankylosis.[1]

Ankylosis may occasionally occur as a congenital condition.

The joint may be stiffened in any part of its normal arc of motion. Ankylosis is more common in a deformed than in a straight position,

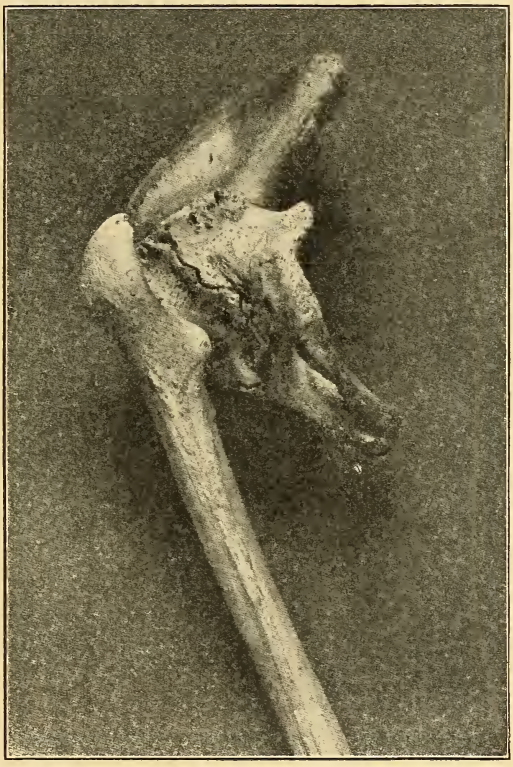


FIG. 220.—Pseudo-ankylosis of Hip-joint Due to Arthritis Deformans. (Joachimsthal.)

when it is the result of chronic joint diseases. The position in which it occurs is of great importance, as the usefulness of a limb in cases of irremediable ankylosis will depend on stiffness in a useful position.

In the hip ankylosis is likely to occur in flexion and adduction. The desirable position for ankylosis of the hip is in a few degrees of flexion with no adduction or abduction.

In the knee ankylosis generally occurs with flexion of the leg with subluxation of the tibia. The useful position is with the leg nearly straight.

[1] Reyher: Deutsch. Zeit. f. Chir., iii., 1873.

In the ankle the desirable position for a stiff joint is with the foot at a right angle to the leg.

In the shoulder the arm is most useful if slightly abducted and a little flexed.

With a stiff elbow the only useful arm is obtained with the forearm at a right angle to the arm.

The diagnosis of ankylosis is made by the absence or limitation of motion. It is not diminished by anæsthesia, and the *x*-ray shows the

FIG. 221.—True Ankylosis of Hip-joint Due to Tuberculous Disease. (Warren Museum.)

disappearance of the line between the bones and the continuity of bony structure in bony ankylosis.

The prevention of ankylosis consists in the efficient treatment of the affections likely to cause it.

The *treatment* of ankylosis when the union is not bony naturally differs from that when the ends of the joint are connected by bone. In the latter case non-operative treatment is useless.

In incomplete ankylosis an attempt may be made to stretch the connecting structures and thus increase the amount of motion.

Manual Stretching.—This may be done by gradual manual stretching, in which gentle manipulative force is used at short intervals and repeated daily. If too much force is used, inflammatory reaction will be

started in the joint, and the condition will be made worse. The use of a proper degree of force should be followed by a daily increase of joint motion without great pain.

Mechanical Correction.—The attempt at stretching may be made by means of a *pendulum* apparatus, in which a carefully controlled rhythmical movement is exerted to any desired extent. The *Zander* apparatus may be used in a similar way to increase the range of joint motion.

Local Measures.—Certain measures affecting the local circulation seem to aid in restoring flexibility in connection with the stretching mentioned above. These are Bier's congestive method, hot-air baths, massage, and vibratory massage.

This treatment is suited to the stiffness following fractures and joint injuries, the loss of motion in arthritis deformans, and after non-tuberculous inflammations in and around the joints.

Forcible Stretching.—In case these measures prove ineffectual the patient should be anæsthetized and the arc of motion of the stiffened joint increased by the use of moderate force to stretch or break the adhesions existing. This should be followed by rest to the joint for one or two days, followed by the resumption of the gentle measures described. The injudicious use of force, as a rule, does more harm than good by exciting inflammation and causing new adhesions. After the use of manipulative force the joint should be fixed in the position of greatest usefulness, described above.

In the case of *bony ankylosis* these measures are of no value.

If the ankylosis has occurred in a position of deformity, the joint should be corrected and the limb placed in a useful position by osteotomy or excision.

Osteotomy is, as a rule, linear, and is generally performed just above or below the joint surface. Wedge-shaped osteotomy inevitably shortens a limb, but may be required in cases of extreme deformity.

Excision may be done at the site of an ankylosed joint, not with a view of restoring motion, but to correct deformity. The planes of the resected ends of the bones should be so placed as to give the desired position of the joint after union.

The application of these methods to the especial joints has been discussed in connection with each joint.

Formation of New Joints.—In bony ankylosis the formation of a new joint at the site of the former one may be attempted. The method of interposing a layer of fascia or other foreign substance between the resected ends of the bone in cases of true bony ankylosis has been described and successfully carried out with marked success, especially by Murphy,[1] of Chicago. The hope of success in the operation depends upon the fact that aponeurosis attached to fatty tissue when subject to

[1] Murphy: Trans. Am. Surg. Assn., xxii., 315 (with literature).

pressure tends to form an hygroma or bursa. If, then, the line of union where the joint formerly existed is chiselled or cut through in approximately the original joint plane, and aponeurotic, or muscular, and fatty tissue is interposed, there is hope of a restoration of joint motion in place of the former bony ankylosis. The capsule and synovial membrane, if the latter remains, are extirpated and only essential bands of ligaments are left. Bony outgrowths are removed, adherent tendons freed, cicatricial contractions cut out, and a flap of the desired tissue is taken from the neighborhood and turned in between the ends of the bones. This flap should be secured to the edges of the capsule and is left attached by its base. Use of the limb is at first painful, and passive motion under anæsthesia may be required. Murphy reports a series of successful cases in various joints. The causes of failure he enumerates as follows:

1. Insufficient or defective exsection of synovial membrane, capsule, and ligaments.

2. Insufficient interposition of fat and aponeurosis or muscle between the separated bony surfaces.

3. Infection.

4. Sensitiveness to pain in motion after operation

CHAPTER IX.

RICKETS, KNOCK-KNEE, AND BOW-LEGS.

Rickets.—Definition.—Pathology.—Occurrence and Etiology.—Symptoms.—Diagnosis.—Prognosis.—Treatment.
Osteomalacia.—Chondrodystrophia fœtalis.—Fœtal rickets.
Knock-knee.—Occurrence and etiology.—Symptoms.—Diagnosis.—Treatment.—Expectant.—Mechanical.—Operative.
Bow-legs. — Occurrence. — Causation. — Symptoms. — Diagnosis. — Prognosis.—Treatment.—Expectant.—Mechanical.—Operative.
Rhachitic curves in the upper extremity.—Improperly united fractures.

RICKETS.

Definition.—Rickets is a constitutional disease which affects young children. Its chief characteristics are manifested in the osseous system, where there is a local or general disturbance of the normal process of ossification, as a result of which the epiphyses become enlarged and the affected bones become soft and pliable; growth is delayed and deformities of a serious character arise. The affection itself does not belong to the category of surgical diseases; but the resulting deformities demand strictly surgical treatment, and it is important that the surgeon should familiarize himself with the leading features of the affection.

The disease is known in English as rickets or rhachitis. Other names for the affection are: morbus anglicus, articuli duplicati, englische Krankheit, Zwiewuchs, doppelte Glieder, nouure, rachitisme, etc.

Pathology.—Rickets occurs especially at the time when the bone growth is at its maximum, and its most obvious feature is a defective calcification of the bones, in consequence of which secondary changes occur.

In rickets the pathological changes are most marked at the junction of the epiphysis and the shaft. The epiphyseal cartilage, which should normally be a thin layer, in rickets appears as a broad, reddish-gray, translucent cushion, while the whole epiphysis is enlarged.

The line of calcification is thin or may be wanting in places, the formation of medullary spaces extends into the zone of calcification and possibly through it, and the deposit of bone inside these spaces is wanting or irregular, its place being taken by "osteoid tissue."

The periosteum of the shaft is hyperæmic and thickened and boggy and often adherent to the bone. The subperiosteal layer, which nor-

mally is thin and scarcely noticeable, in rickets is thick and appears dark and like spleen pulp.

The medullary bone is more hyperæmic than normal medulla at this age. The intercellular substance may show mucoid degeneration or be fluid. It does not seem that lime is dissolved out of the finished bone, but that resorption of such bone *in toto* is the important element. After the active process has ceased lime is deposited in the "osteoid tissue," and the result is a thick and heavy bone.

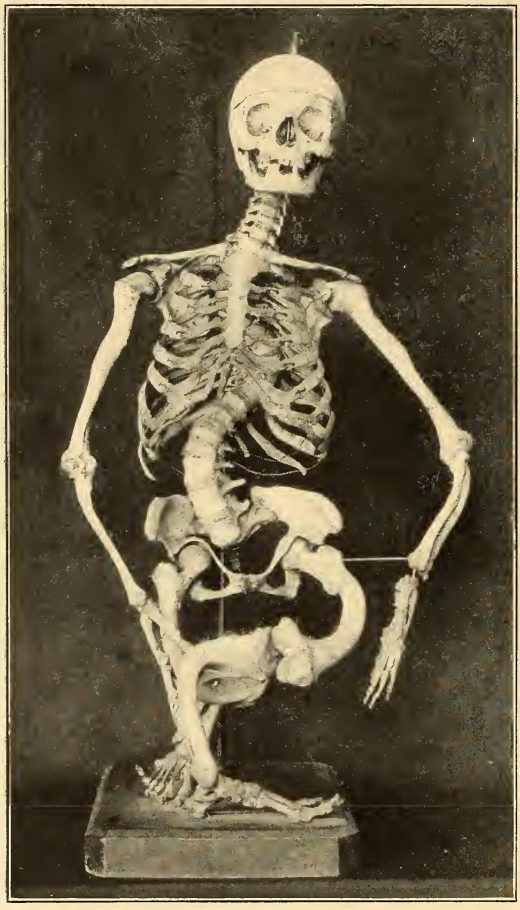


FIG. 222.—Skeleton in Rickets. (Warren Museum.)

The chemical analysis of rhachitic bone shows a percentage of nineteen to fifty-three per cent of ash.

Ossification after the process is over becomes excessive and may be spoken of as petrifaction or eburnation, rather than true ossification. Infractions or partial fractures, with the break on the concave side of the long bones, may occur. The ligaments become relaxed and stretched, and the muscles flabby from disuse. The spleen is ordinarily enlarged and sometimes the liver. Catarrh of the alimentary canal and bronchi are common accompaniments.

In rickets of the skull the meninges and brain may be secondarily affected.

Occurrence and Etiology.—Rickets is an affection occurring commonly during the first dentition. Cases of rickets are, however, described as congenital and others as occurring during adolescence.

Congenital rickets, or fœtal rickets, will be discussed under the heading of *chondodystrophia fœtalis*.

Rickets in Childhood.—The common time of occurrence is in early

childhood, especially in the first two years of life. In a series of 400 medical out-patients consecutively investigated at the Infants' Hospital, Boston, 318 showed signs of rickets, and in 106 of these the children were in their first six months, 134 between six and twelve months, and the remainder between one and two years.[1]

The rickets of adolescence or late rickets is a disease which affects persons at about the age of puberty;[2] it may be[3] associated with albuminuria, and its etiological relations are decidedly obscure. The physical signs are the same as in the rickets of early life, except that the epiphyseal enlargement is generally not so great. In several cases reported dissection of the skeleton showed the same characters as in early rickets.[4]

In 2,595 cases of rickets reported from various authors, there were 1,337 boys to 1,258 girls.

Causation.—Rickets is an affection of faulty nutrition. It is much more prevalent among the crowded poor of the cities than in rural communities, and certain races seem to be more subject to the affection than others. The children of the negro, Italian, and Portuguese poor are more frequently afflicted than the Irish in our Atlantic American cities.

As might be expected, the later children of a large family are much more liable to rickets than their older brothers and sisters.

Inasmuch as rickets is a disease of malnutrition, the commonest causes are to be sought in the immediate surroundings of the patient.

Bad hygienic influences, such as poor ventilation and food, damp dwellings, crowded rooms, etc., have a very marked influence in producing rickets.

The most evident cause other than bad environment is faulty feeding. The disease is much less common in breast-fed than in bottle-fed children. In the latter, even if carefully nurtured, slight evidence of rickets is not infrequently seen in late dentition or enlarged epiphyses, and occasionally in slight curves in the long bones.

As to the theories of the causation of rickets, the reader is referred to books on the diseases of children.

Artificial farinaceous foods contain a very much smaller percentage of fat than milk does, and the experience at the London Zoölogical Gardens lends much weight to the idea that the deprivation of fat and

[1] J. L. Morse: Journ. Am. Med. Assn., March 24th, 1900.

[2] Lucas: Lancet, June 9th, 1883.

[3] Keetly: Annals of Surgery.—Palm: Practitioner, xlv., 1890. p. 275.—Duplay: Gaz. des Hôp., 1891, p. 1397.—Robert Jones: Brit. Med. Journ., 1896, i., 341.

[4] Moxon: Guy's Hospital Reports, 1878.—St. Thomas' Hospital Reports, vol. xiv.

proteids from the diet of young animals is a most important factor in the production of rickets. In menageries, where animals live under highly artificial conditions, rickets attacks young lions especially, and is the cause of death in a large number of cases. Ostriches, pheasants, and poultry under the same conditions have a softened condition of the bones.

The subject of the relation of syphilis to rickets must be passed over very briefly, as having only an incidental interest in this treatise. The present view rather regards syphilis as an indirect cause of rickets in impairing the general constitution. The common experience is to find a small proportion of syphilitics among rhachitic children.

Chronic tuberculosis in the parents, as well as debility from any cause impairing the nutrition, may be the cause of rickets. Any exhausting disease in the child may be followed by rickets, while bronchitis is too common a symptom of rickets to be considered its cause, as some writers would do. Finally, in certain rare cases no cause can be assigned for the occurrence of the affection.

Symptoms.—The disease is so often the outcome of a long period of ill-health that it is difficult to say when the rhachitic symptoms begin. Among the commonest early symptoms are restlessness at night, profuse sweating, especially of the head, and constipation perhaps alternating with diarrhœa, but the diagnosis cannot be made from the premonitory symptoms.

The belly becomes large and distended with symptoms of imperfect digestion and faulty assimilation. In the severer cases the child may suffer great pain on being moved.

The so-called "paralysis of rickets" is at times an accompaniment of this stage, and is generally brought to the parent's notice by the child's inability to use the limbs. The thighs and upper arms are the regions most commonly affected. There is no lesion of the nervous system in these cases, and a careful examination in the recumbent position shows that the child's muscular movements are impaired from the pain caused by movement. The disability is to be attributed to the muscular weakness and the bone tenderness, particularly to a periosteal tenderness at the muscular insertions. The electrical reaction is normal and the reflexes are not affected. This pseudo-paralysis is an early symptom of rickets, and as a rule precedes any marked osseous change, which adds to the difficulty of its recognition. The most difficult affection from which to distinguish it is the disability due to simple weakness in non-rhachitic children.

Fever is most often absent or due to some complication, such as bronchitis. Convulsions may occur at any stage of the disease, especially when there is any tendency to craniotabes.

Changes in the Bones.—Enlargement of the epiphyses appears,

especially at the wrists and anterior ends of the ribs. Enlargement of the lower end of the radius and ulna is practically universal, whereas enlargement of the lower end of the tibia and fibula is less frequent. These enlargements do not involve the joints. At the ribs one finds the "rosary," a series of bead-like enlargements easily felt at the junction of the cartilages and the ribs, and a small degree of epiphyseal enlargement is easily detected here, and not likely to be mistaken for anything else. When these changes have occurred, the bones have already softened and curvatures of the long bones may have begun. In the deep-seated epiphyses, like the hip and shoulder, one does not notice the change.

The forces that work to produce deformity in the softened bones are muscular action, gravity, pressure from weight, atmospheric resistance, and the pressure exerted on bony structures by growing organs.

The typical *head* of rickets has a high, square, prow-shaped forehead, with a decided prominence of the lateral parts of the frontal bones (frontal eminences) and sometimes the parietal eminences as well.

The *anterior fontanel*, which should normally close at about the eighteenth month, remains widely open and does not ossify until perhaps the third year or even later This, however, is not enough to establish the fact that the child is rhachitic until the age of two years has been reached. The posterior fontanel sometimes remains open for months.

FIG. 223.—Case of Rickets Showing Deformity of Chest and Enlarged Abdomen. (J. S. Stone.)

The name *craniotabes* is applied to an abnormal thinness of portions of the parietal and occipital bones.

Hyperæmia of the brain and meninges may be an accompaniment. With this hyperæmia comes the likelihood of hydrocephalus, either external or internal, and the accompanying cerebral changes, so that hydrocephalus becomes a complication of rickets which is not very rare.

Deformities of the chest are among the most common produced by rickets and they occasionally exist without any well-marked signs of rickets elsewhere. It is not unusual to see young girls about the age

of puberty who have discovered some inequality in the chest or prominence of the lower ribs perhaps, but who present no other signs of rickets. In these cases it seems reasonable to assume that a slight degree of bone softening existed in childhood and passed away without leaving any other sign than the chest malformation.

In a typical rhachitic chest the clavicles are shorter and more curved than they naturally should be. The chest is narrow and prominent in front; it shows the effect of lateral compression, and the sternum projects so prominently that the name of pigeon breast, or pectus carinatum, is commonly given to it. The weakest part of the chest cavity is at the junction of the ribs and cartilages, and it is here that the chief yielding takes place and the ribs allow themselves to be pressed in laterally, while the sternum is pushed forward. Again, one side may yield more than the other and a prominence of the front part of the ribs on one side of the sternum may be the only deformity. A transverse depression in the chest known as Harrison's sulcus also occurs in the typical cases. It is most evident just below the nipples. The prominence of the abdomen, which is almost universal in well-marked rickets, adds to the deformity of the chest by the elevation of the lower ribs, on account of the underlying distention. When the abdominal distention disappears, this flaring of the lower part of the ribs is sometimes left behind.

A very common deformity of the *spinal column* due to rickets is a backward bowlike curve (involving the dorsal and lumbar regions). It is a uniform flexion of the whole column and is most prominent at the junction of the dorsal and lumbar regions. This attitude seems the result of a long-continued sedentary position, with a weakness and tenderness of the muscles, which fail to hold the spine in the erect position. Rhachitic children, as a rule, learn to walk late, and this peculiar flexion seems a persistence and exaggeration of the position which the spine naturally assumes in young babies, who are propped up in the sitting position. The curve of the spine is usually rounded rather than sharp, and the prominence is not limited to one vertebral spinous process, as is the case in early Pott's disease.

The rhachitic curve of the spine is, as a rule, flexible if the child lies upon its face and is lifted by the legs. In the acuter stages and after marked bone changes have taken place some stiffness may be seen.

Scoliosis is a common deformity due to rickets, which has already been considered.

Lordosis is the third of the common spinal deformities due to rickets, and gives rise to a characteristic attitude, the importance of which is much overlooked.

The *attitude* of a child affected with well-marked rickets is characteristic. It exists in most marked cases of knock-knee and bow-legs

and sometimes in a less degree with milder grades of the affection. The child stands with the legs apart, the thighs flexed and the knees bent, the back is arched, and the shoulders are thrown back. The cause of this attitude has never been quite clearly established. It is undoubtedly in a measure the persistence of the infantile attitude, the position which children assume who are just learning to walk. Another factor is the protuberant abdomen, the weight of which the child seems to counterbalance by leaning backward.

Deformity of the *pelvis* is induced by rickets, because the body weight is borne by a bony arch which has lost part of its supporting

FIG. 224.—Deformity of Spine in Rickets.

power and bends under weight. These pelvic deformities have only a significance in regard to obstetric surgery; they occasion no trouble or noticeable deformity in themselves, but in females, when pregnancy comes on, their existence is a matter of the gravest importance. The subject is treated in books upon obstetrics.

Except in very severe cases, the *arm* bones are not seriously curved. The curvatures follow no especial rule, but generally they are an exaggeration of the normal curves of the bones. The curvature of the arm bones may be due to creeping or to lifting the child continually by taking hold of the forearm in one place, but often apparently is the result of muscular action.

Coxa vara may exist in the hips. The condition will be described in chapter X.

The rhachitic deformities of the legs are of such importance that they will be considered under the separate headings of knock-knee and bow-legs.

Flat-foot is a very common accompaniment of rickets. The affection is considered under flat-foot.

In general, the skeleton is not only deformed but stunted, and persons who have rickets severely in childhood do not reach average size

FIG. 225.—Attitude of Severe Rickets, Showing Lordosis and Rotation of Pelvis.

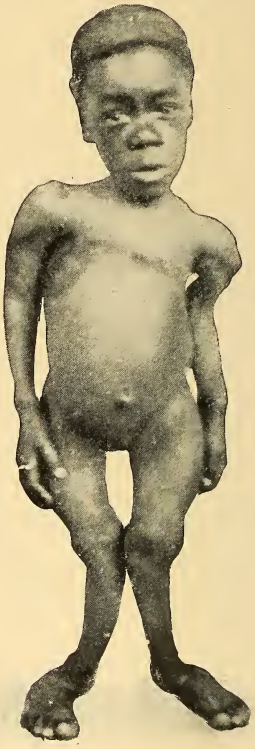


FIG. 226.—Extreme Deformity from Rickets.

in adult life, as a rule. The osseous deformities, in most cases, persist to a certain extent through life. Notably is this true of the shape of the skull and the chest.

Important symptoms relate to the eruption of the *teeth;* not only are they late and irregular, but they are imperfect generally, and unable to resist decay. On the average the first tooth appears about the ninth month, and not only is the interval between the teeth longer, but the order of appearance is often abnormal.

Diagnosis.—The diagnosis in fully developed rickets is simple; but when the affection is beginning, its recognition may be attended with difficulty.

In beginning rickets certain symptoms are suggestive; these are restlessness and sweating at night, and especially universal tenderness when acute articular rheumatism is not manifestly present. In well-marked cases the diagnostic points are the epiphyseal enlargement of the ends of the long bones, especially the wrists and the sternal ends of the ribs; the prow-shaped head; the deep, small chest; and the big belly. Delayed dentition and an anterior fontanel open long beyond the proper time are equally characteristic. If the disease has advanced still further, one often finds curvature of the bones of the legs and arms.

Delay in learning to walk should also excite suspicion of the presence of rickets.

Differential Diagnosis.—From Pott's disease rhachitic spinal curves are sometimes not easily distinguished. Young children a few months old are not infrequently brought for examination on account of a prominence in the back and a great deal of crying in being lifted or handled. At the junction of the lumbar and dorsal regions a prominence may be present, involving several vertebræ, which may or may not be obliterated when the child lies on its face and is lifted by its feet from the table. Sometimes the constitutional evidences of rickets are so marked that the diagnosis is clear; Pott's disease, when it occurs in young children, begins often in this location and in this way. The writers have seen cases in which doubtful kyphoses of the same characteristics have been kept under observation and treatment, and one case has proved to be rhachitic, while another developed into clearly marked Pott's disease. Rhachitic kyphosis is more common than Pott's disease in children under eighteen months, and, although the presence of rickets does not rigidly exclude the possibility of Pott's disease, yet when the general signs of rickets are present, it is safe to assume that in most cases the kyphosis will disappear under treatment. In doubtful cases time alone will clear up the question.

Prognosis.—When the disease is left to itself it generally runs its course, and after a decided degree of bony deformity has occurred the process of bone softening is spontaneously arrested, and the bones harden in their deformed condition.

Spontaneous arrest of the disease may take place at any stage without treatment, but, as a rule, in severe cases not before a serious degree of bony deformity has been produced. When the disease is treated efficiently, the prognosis as to life is always favorable, unless some serious complication is present, and the disease is, as a rule, easily amenable to treatment.

The kyphosis above alluded to disappears or diminishes with the growth of the child. Lateral curves, however, are more permanent. As a rule the bony deformities, such as epiphyseal enlargement, diminish with growth, but remain through life to a certain degree.

Treatment.—The treatment of rickets consists, first, in the proper feeding of the child. For what this food should be the reader is referred to works on the diseases of children. In addition to this diet, it is desirable to give to rhachitic children of over six months meat juice or raw beef in small quantities and orange or lemon juice. Drug treatment is manifestly secondary in importance to careful regulation of the diet and hygiene. A remedy much advocated in the treatment of rickets is phosphorus. It is given in doses of $\frac{1}{100}$ to $\frac{1}{150}$ of a grain three times a day. It may be given in the form of the officinal phosphorated oil mixed with olive or almond oil. The writers have seen but little benefit from its use, and believe that simple tonics accomplish as much as any drug. The syrup of the iodide of iron seems a useful preparation. Cod-liver oil is of use.

Hygiene and General Surroundings.—Rhachitic children should be bathed daily, preferably in salted water, and rubbed vigorously. Warm woollen clothing should be worn and they should go out daily. Especial care should be taken to keep them in sunny, well-ventilated rooms; their meals should be regular, and they should be obliged to eat slowly. The bowels should be watched and kept regular, and every care should be paid to keeping the child's general condition as good as possible in every way. The seashore hospitals, now established in Italy, France, Germany, and America, provide, with proper nursing, air, and food, the best prophylactic against rickets.

The discussion of the operative and mechanical treatment of rickets will be taken up under the head of knock-knee and bow-legs.

OSTEOMALACIA.

Osteomalacia is a process somewhat similar to rickets in causing softening of the bones. Although the pathological processes in the two diseases are distinct, there is a question whether the two diseases are not more closely allied than has been supposed.[1]

In osteomalacia there is absorption of the lime salts, beginning in the marrow of the bone and affecting first the spongiosa. The medulla becomes hyperæmic and there is an increase of lymphoid and fatty elements. The medullary cavity extends at the expense of the cortical part, and the resistance of the bone is so impaired that it bends or breaks. The periosteum is likely to be thickened and vascular. There is some tendency to new bone formation, especially at the site of fract-

[1] Joachimsthal: Handb. der orth. Chir., 1904, i., p. 77.—Kassowitz: Wiener med. Woch., 1901, 38.—Morpurgo: Cent. f. allg. Path., xii., 1902.

ures. The disease is most prevalent among the lower classes, and it affects certain localities more than others. Females are attacked more often than males.

The disease may be divided roughly into the puerperal and the non-puerperal form.

The former occurs during pregnancy and attacks the pelvis most often, extending perhaps to the spine and other parts later. The outlook for recovery is more favorable in this form.

The non-puerperal form may attack children or adults of any age.

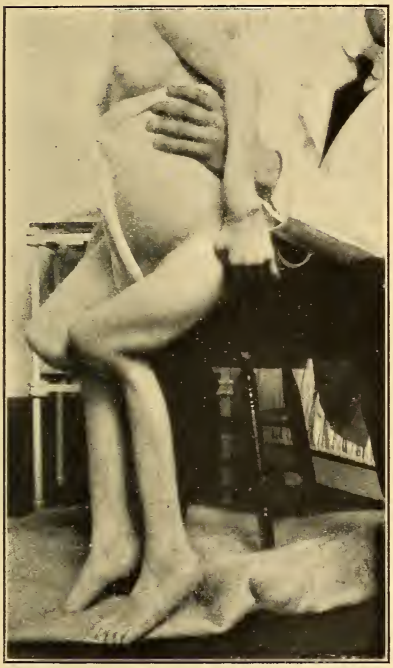


FIG. 227.—Case of Osteomalacia in a Girl of Fifteen Years. Showing deformities of legs and arms. (C. F. Painter.)

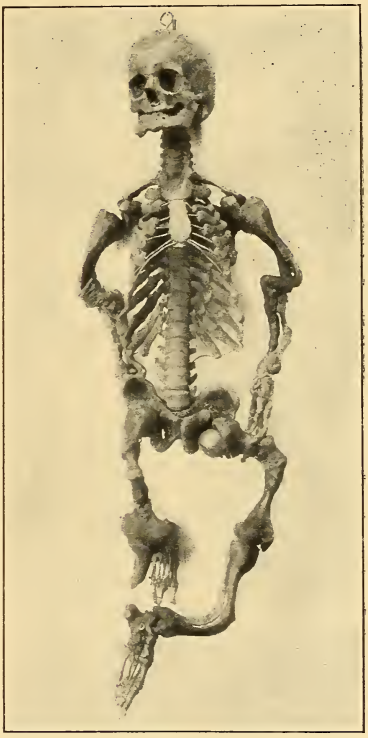


FIG. 228.—Skeleton in Osteomalacia. (Warren Museum.)

Its etiology is unknown, and it begins most often in the lower extremities or in the skull. The progress is slow and the outlook unfavorable.

The symptoms consist of dull pain and perhaps tenderness in the affected parts, hyperæsthesia of the skin, and discomfort in walking or sitting. This is followed or accompanied by yielding of the bones and fractures, complete or incomplete.

Osteomalacia in children is seen at times, and its relation to

rickets is obscure.[1] Both conditions may evidently exist in the same patient.[2]

The treatment of the disease must be directed to the relief of the symptoms and must be conducted on general principles.

CHONDRODYSTROPHIA FŒTALIS.

Chondodystrophia fœtalis (achondroplasia—fœtal rickets).

Although this condition is described frequently under the name of fœtal rickets, it is essentially a different pathological process.[3] Clinically the children at birth seem to present the signs of a severe grade of rickets which has run its course. The head is large and the bridge of the nose depressed. There is beading of the ribs and perhaps flattening of the sides of the chest. The long bones of the extremities are shortened and perhaps bowed and enlarged near the joints.

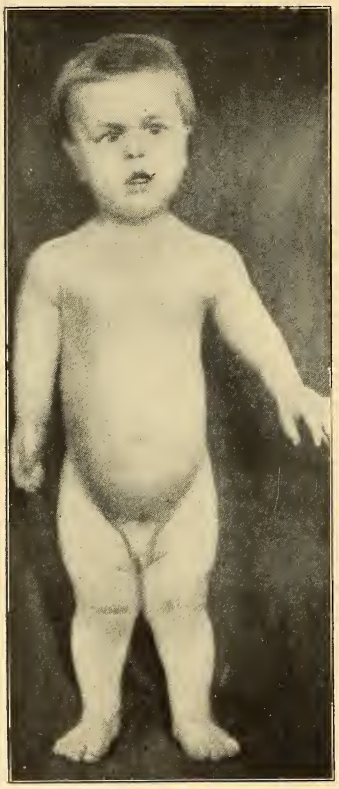


FIG. 229.—Chondrodystrophia Fœtalis, "Congenital Rickets."

The essential pathological process is, however, a disturbance of the normal process of ossification of the primary cartilage. The cartilage atrophies and the process of ossification takes place abnormally early. The affection apparently begins between the third and sixth months of intrauterine life and has almost ceased at birth. It does not involve bones which exist only in cartilage until a late period of intrauterine life, and this accounts for its distribution. The medullary canal of the long bones is diminished in size and there is a periosteal overgrowth at the epiphyses simulating the real enlargement occurring in rickets.

In true chondodystrophia the bones will remain distorted, the joints will probably be limited in their range of motion, and the general growth of the body retarded. The milder cases may reach adult life.

[1] Roos: "Schwere Knochen-Erkrank. im Kindesalter—Osteomalacie? Rachitis?" Zeitsch. f. klin. Med., lv., 1903.

[2] Recklinghausen: Wien. med. Woch., 1898.—Joachimsthal: Handb. f. orth. Chir., 1904, i., p. 79.

[3] J. L. Morse: Arch. of Pediatrics, August, 1902 (with bibliography).

The treatment can only be palliative, and must consist of manipulation and massage of the restricted joints and the prevention of bowing of the spine when it is threatened by the use of a brace or by rest in the recumbent position.

Congenital rickets is a name that may be applied to cases in which ordinary rickets obviously exists at birth, but not to those cases in which it has reached the severe grade just described.

KNOCK-KNEE AND BOW-LEGS.

The surgical interest in rickets is centered on the bony deformities which result from the disease and persist after the morbid process has ceased its activity.

The curves of the bone are various, but those which are chiefly interesting to the orthopedic surgeon are those of the lower extremity, knock-knee and bow-legs.

KNOCK-KNEE.

Knock-knee, or *genu valgum*, is the name applied to an internal angular prominence of the knee, in which the bones of the leg form an abnormal lateral angle with the bones of the thigh, and this angle opens outward.

This condition is also known in English as in-knee; in Latin as genu introrsum; in German as Knickbein, X-bein, Bäckerbein, Ziegenbein, Kniebohrer, Knieng, and Schemmelbein; in French as genou cagneux, genou en dedans; and in Italian as ginocchio torto all' indentro.

Occurrence and Etiology.—The deformity is one of common occurrence, but not so common as bow-legs. In 12,694 cases of orthopedic affections treated at the Children's Hospital, Boston, there were 1,807 cases of bow-legs and 753 cases of knock-knee. Both deformities affect boys more often than girls.

Knock-knee is a deformity which appears for the most part shortly after the children learn to walk; it appears also between the ages of twelve and eighteen. Exceptional cases occur at any age.

Knock-knee occurring in the first period named is almost always associated with general rickets, and is sometimes called *genu valgum rhachiticum*, to distinguish it from the form occurring at puberty, which is spoken of as *genu valgum staticum* or *adolescentium*. Many efforts have been made to identify this later form also with rickets, to consider it a local rhachitic process, a form of "latent rickets." The form of knock-knee occurring in adolescence especially affects persons whose occupation compels them to be most of the time in a standing position, and, as a rule, those affected are individuals of feeble physique.

Other cases of knock-knee are produced as a late result of muscu-

lar paralysis. Fractures about the joint and destructive ostitis of the knee are also causes of knock-knee in their late history.

Mechanical Production of Knock-knee.—While the chief cause of the deformity seems to be a static one, due to the superimposed body weight, pressure from faulty position and abnormal strain, as has been shown by Dane, may be a factor in the production of bony curves. Other causes are to be found in peculiar gait, distributing the weight and strain in an unusual manner.

The normally formed human being in the upright position stands with a certain amount of knock-knee. The femurs form an angle of 15° with each other and sometimes more, and, as a result of this oblique direction, the inner condyle of the femur must be longer than the outer. When a normally formed person stands erect with the heels together, if a plumb line be dropped from the head of the femur it will be seen to fall outside of the centre of the knee-joint; and this will happen to a greater extent in the female than in the male.

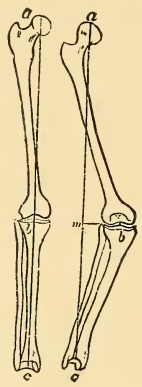


FIG. 230.—Axis of a normal leg, and of one Affected with Knock-knee.

It is therefore evident that the external condyle of the femur and the corresponding facet of the tibia transmit more body weight than do the corresponding internal articular surfaces, because the centre of gravity lies outside of the centre of the joint.

To maintain an erect position with the feet together requires muscular action. If the standing position is to be maintained for a long time, or for a short time in the case of children or feebly developed adults, the instinctive disposition is to substitute ligamentous for muscular support. This can be accomplished by keeping the knee extended and separating and everting the feet. It is the attitude assumed by children learning to walk and by tired adults. This attitude is often spoken of as "the attitude of rest."

From this position more weight than before is transmitted through the external condyle and less through the internal one. If angular deformity takes place finally, all the weight is transmitted through the external condyle.

Two results may follow from this: stretching of the internal lateral ligament and atrophy of the external condyle.

The stretching of ligaments when subject to undue tension is too familiar a pathological process to require comment. The atrophy and retarded growth of bone, and especially rhachitic bone which is subjected to pressure and strain, are well known.[1]

[1] Lane: Guy's Hosp. Rep., vol. xxviii.

Flat-foot ordinarily coexists. Sometimes it must stand in a causative relation to knock-knee; sometimes it is more the result than the cause, but commonly they are both the results of the same faulty attitude, assumed as a result of muscular fatigue and weakness. Flat-foot is more easily produced than knock-knee, and is more common.

It is proper to recognize the class of cases when the femur is apparently normal, but the articulating surfaces on the head of the tibia are oblique.

FIG. 231.—Slight Knock-knee.

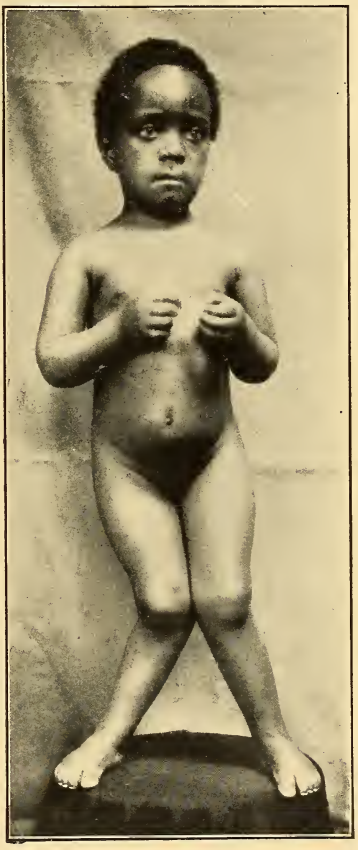


FIG. 232.—Moderate Knock-knee.

In still a third class of cases the deformity is due not so much to primary joint obliquity as to a bend in the diaphysis of the femur or the tibia just above or just below the joint.[1]

There are, then, three bony deformities likely to be found in cases of knock-knee, viz.:

[1] Arch. f. klin. Chir., 1879, xxiii.

(*a*) Difference in the size of the condyles of the femur.

(*b*) Inequality in the articular facets of the tibia.

(*c*) Bending of the diaphyses of the bones above or below the joint.

In severe cases the tibia is found to be rotated outward.

The internal ligaments are hypertrophied, and the muscles and tendons on the inner aspect of the leg are, of course, stretched. The patella lies farther outside than it should do. In some it may be seen that the outward rotation of the tibia is so marked that a sort of compensatory inversion of the feet has been acquired almost to the condition of varus to aid in keeping balanced.

FIG. 233.—Severe Knock-knee due to Rickets. Seen from behind.

FIG. 234.—Slight Knock-knee Resulting from Tuberculous Disease of the Left Knee. Now cured.

Symptoms.—Subjective symptoms in knock-knee are almost always absent. Children and adults tire more easily than they should when they have knock-knee, and sometimes pain and sensitiveness are complained of over the internal lateral ligament of the knee; as a rule those with knock-knee are clumsy and have a poor sense of balance. In young children with knock-knee and active rickets locomotion is generally difficult, while in adult cases there is less difficulty in walking,

even in severe cases, than would be expected from the degree of the deformity.

In the standing position it is noticed that the knees are unduly prominent on the inside aspect of the leg, and that the tibiæ diverge so that the feet are perhaps only a few inches apart, or, again, in severe cases, a considerable distance. In cases in which the angular deformity is very great, the patients find the easiest position for standing is with one knee behind the other, so that in this way the feet may be brought together.

If the child stands with the feet together one knee is generally a little hyperextended and the other slightly flexed, so that they apparently come together.

The gait of a patient with double knock-knee is distinctive. The gait is a rolling one, consisting of a series of slight lurches, which are, however, not nearly so marked as in bow-legs or congenital dislocation of the hip; while what is particularly noticeable is the outward throw of the leg when it is being brought forward.

The gait is, moreover, slightly modified by the fact that in severe cases the thighs and consequently the knees are slightly flexed. "Toeing in" is common, even in the slighter grades.

When the deformity is unilateral the limp is less marked. Lateral curvature is sometimes induced by the unilateral deformity.

On manipulation, the knee-joint is often movable in a lateral plane through an arc of several degrees. In these cases the deformity is, of course, increased when weight is put upon the affected leg, so that in walking and standing it reaches its maximum.

The angular deformity disappears when the knee is flexed to a right angle, except in cases in which the chief deformity is in the tibia. But if the knee be flexed while the hip-joint is still extended, the deformity does not entirely disappear, though it is very much diminished.

The practical point is, that as the deformity is most severe when the leg is in the extended position, all mechanical treatment applied to the correction of knock-knee must be to the fully extended leg. When the leg is fully flexed the inequality in the length of the condyles is most evident, as seen in outline from the anterior surface of the thigh. This may be registered by shaping a lead strip to the lower surface of the femur when the knee is fully flexed, and drawing an outline on paper from the lead strip, which should be stiff enough to keep its shape.

Occasionally one sees a combination of knock-knee and bow-legs in the same subject.

Loose Knees.—In young children beginning to walk, who have grown rapidly or who have perhaps the mildest degree of rickets, there is often developed a laxity of the knee-joint which may require treat-

ment. On account of the mechanical conditions explained above they stand with the knees prominent inward, but the deformity disappears on lying down and no overgrowth of the internal condyle is to be found. The knees can easily be hyperextended and are abnormally movable laterally. Such children are unsteady on their feet and the apparent knock-knee is noticed. The treatment consists of the measures to be described in speaking of the mildest cases of knock-knee.

FIG. 235.—Bow-leg of Right Leg, Knock-knee and Flat-foot on Left.

FIG. 236.—Hyperextended Position of the Knees, Frequently Seen in Connection with Knock-knee.

Measurement of the Deformity.—The simplest and most reliable method of registration is to have the patient sit upon a sheet of brown paper with the legs extended and the feet pointing upward; and then, with a pencil held perpendicularly to the paper, to trace the outline of the legs. No other method can give so accurate an idea of the degree and character of the deformity present, or can afford so delicate a means of watching and recording the progress of the case.

Diagnosis.—The diagnostic points which mark the affection known

as knock-knee are an inward angular deformity at the knee which disappears on flexion of the leg upon the thigh. There is also in the latter position to be noted a relative prominence of the internal condyle of the femur in nearly all cases.

In children the large proportion of all cases are rhachitic and static, while in adults the purely static cause must be assigned. It is not, in general, justifiable to assume rickets as the cause of knock-knee in cases in which there are no distinctive signs of rickets.

Paralytic knock-knee occurs only in severe grades of paralysis. Its diagnosis is evident from the wasted and contracted condition of the paralyzed limb.

Knock-knee from destructive disease of the knee-joint is a result of severe tumor albus and not of the lighter grades.

Traumatic knock-knee is of two kinds: (*a*) Resulting from osteotomy for genu varum and overcorrection of the deformity; (*b*) resulting from fractures of the condyles of the femur or of the articular facets of the tibia, which are liable to cause lateral malposition of the knee.

The *x*-ray is of use in defining the chief location of the deformity when necessary.

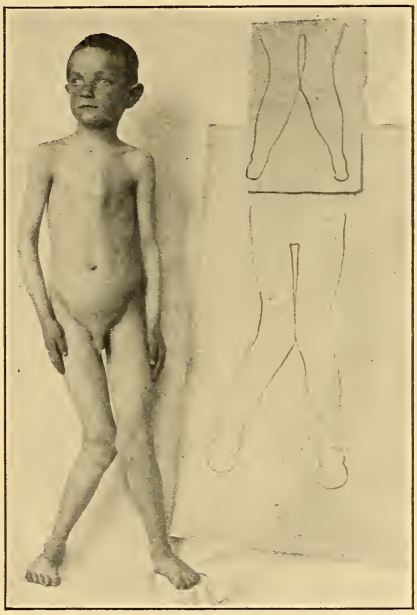


FIG. 237.—Case of Knock-knee, Showing also the Tracings of the Legs at an Interval of Four Years with no Treatment.

Prognosis.—In severe cases it is evident that so much harm has been done already, and the bones have come into such faulty apposition, that spontaneous improvement is not to be expected. Children with a slight degree of knock-knee which is not progressive will probably outgrow it without any treatment if in vigorous health. But if the deformity is moderate or severe, the chances are strong that the affection will remain stationary or more probably will become worse as time goes on, unless active treatment is begun.

Treatment.—The treatment of knock-knee falls into three divisions: I. Expectant. II. Mechanical. III. Operative.

I. The *expectant method of treatment* relies upon nature's efforts to repair the deformity; efforts which are aided on the part of the surgeon by keeping the child off of its feet to a greater or less extent, and by constitutional treatment and by massage and corrective manipula-

tion. In mild cases there is a tendency to outgrow the deformity, but this tendency is at a great disadvantage mechanically, nor is it a safe proceeding to wait for this spontaneous cure in any marked case of knock-knee. The difficult question in the whole matter is to decide which cases can be left to themselves—a question which cannot be answered categorically.

An argument for the spontaneous outgrowth of knock-knee is found in the rarity of adult cases which present themselves at clinics.

When the expectant method is chosen in rhachitic knock-knee, the child should at once be put upon the constitutional treatment for rickets. If the knock-knee is merely the outcome of a feeble general condition, the patient should be most carefully looked after in the matter

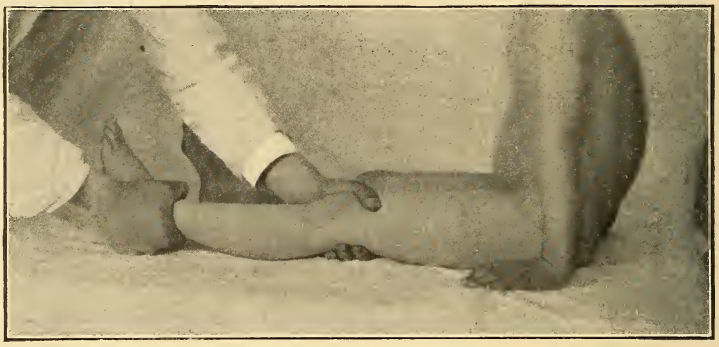


FIG. 238.—Manipulation in the Treatment of Knock-knee.

of hygiene, and tonic treatment and gymnastics should be given, the aim of which should be to strengthen the leg muscles. As much as possible the patient should be kept off of the feet, and a change to country air is capable of effecting great local improvement in feeble children.

The legs should be rubbed and manipulated each night. The rubbing should be the same as that described under infantile paralysis, and the manipulation, in cases of knock-knee, should be directed to the gentle correction of the deformity by repeated mild manual pressure. With one hand the manipulator presses the knee outward, while with the other he presses the lower part of the tibia inward. Even with a very slight degree of force a certain yielding can be felt in the direction of improvement, and then the pressure should be relaxed and the limb allowed to resume its first position. This manipulation should be repeated many times, continuing each pressure only a few seconds. Nor should it ever be done forcibly or long enough to make the child cry. This manipulation faithfully carried out is an important adjuvant, not only of expectant but of mechanical treatment.

In no case should expectant treatment be considered when the child is not under sufficiently close observation to be seen every few weeks, and to have tracings taken to determine whether the deformity is improving or is stationary.

It is advisable in early knock-knee to raise the inner border of the foot in order to bring the line of weight bearing at the knee as far outside as possible. For this purpose felt pads shaped to support the arch of the foot are of use, or the inner border of the sole and heel of the

FIG. 239.—Knock-knee, Irons Applied. Front view.

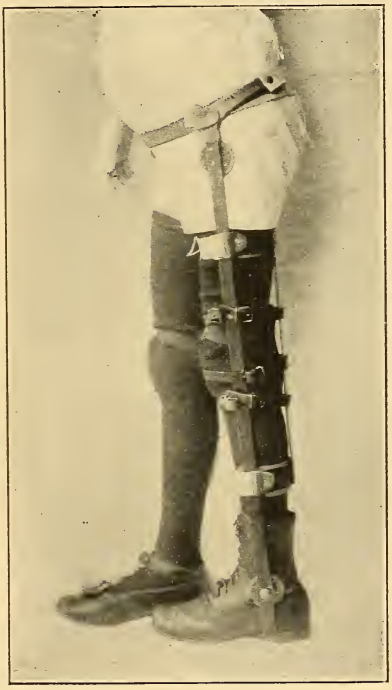


FIG. 240.—Knock-knee, Irons Applied. Side view.

shoes may be made one-eighth or one-fourth inch thicker than the outer border in order to accomplish the same object.

II. *Mechanical Treatment.*—Treatment by apparatus aims at the gradual correction of the deformity, commonly by making counter-pressure against the internal condyle to prevent the further giving way of the knee and to pull it outward to a fixed point furnished by an outside upright. Upon this principle all modern apparatus is constructed.

In children in whom the change known as eburnation has succeeded rickets, the bones are so hard and unyielding that it is almost hopeless, by means of such mild traction as can be exerted, to pull the knee back into place. In general terms, it is not probable that mechanical treat-

ment will be of use after the age of four years has been reached except in slight cases; nor is osteotomy or osteoclasis likely to be considered before that time. Under this age in moderate degrees of deformity the

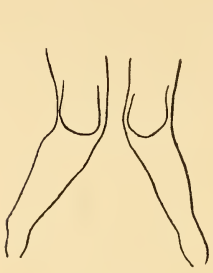


FIG. 241.

FIG. 242.

FIGS. 241 and 242.—Knock-knee. Mechanical treatment for one and one-half years.

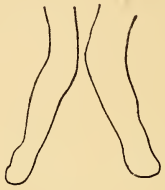


FIG. 243.

FIG. 244.

FIGS. 243 and 244.—Knock-knee Cured in Three Years by the use of Simple Outside Upright. A good average result.

outlook is good with mechanical treatment, and the younger the patient the better the outlook.

Former orthopedic methods are exemplified by methods of recumbency, a method which has practically become obsolete.

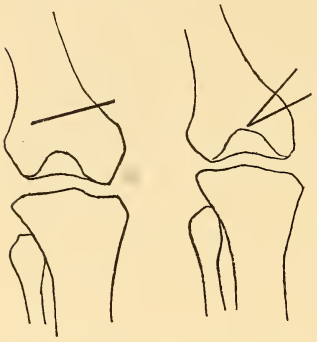


FIG. 245.—Line of Cutting in Osteotomy for Knock-knee. The picture on the left is the ordinary Macewen operation. The one on the right shows the removal of a wedge of bone required only in the severest cases.

In the ambulatory treatment of the affection, a form which has been in use for some years at the Children's Hospital (Chapter XXI., **18**) has proved itself efficient in practical use. It is a light steel rod attached below to a steel sole plate and jointed at the ankle. It runs up the outside of the leg as far as the trochanter, and then the rod is bent backward and upward, to lie against the upper part of the buttock and to serve as an arm by which the legs can be everted if the child toes in in walking. The knee is drawn upon by a square leather pad, pulling from the shaft opposite the knee.

There is no advantage in carrying the outside uprights to a rigid waist band, as is done sometimes. Braces are worn until the line of the leg becomes practically normal.

III. *Operative Treatment.*—The modern operative treatment of knock-knee is comprised under the simple operations of osteotomy and osteoclasis.

Osteotomy.—The operation consists in the division of part of the

bone by the chisel, and the completion of the procedure by fracture of the partly divided bone.

The operation is performed as follows: The patient's leg is rendered aseptic; the patient lies on his side with the leg extended, the outer side of the knee resting on a sand-bag. The skin and underlying tissues may be divided with a knife over the point of division of the bone, or, what is more simple, the chisel is driven through the sound skin into the bone without any incision. This diminishes the bleeding and

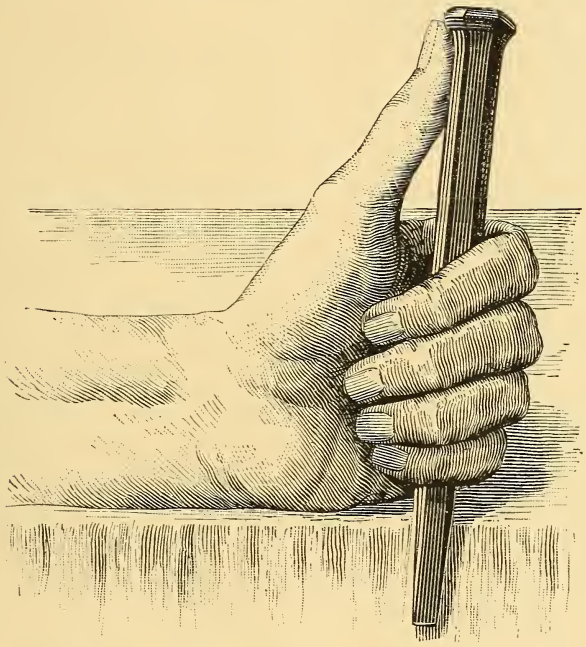


FIG. 246.—Proper Position for the Hand and Osteotome in Performing Osteotomy.

simplifies the operation. The use of an Esmarch bandage is unnecessary.

The point selected for fracture is the point at which the chisel is to be inserted. This should be as near to the joint as is practicable without injury to the joint. The chisel can be inserted on the inner or outer side of the femur. There are no especial advantages of either side for the point of entrance of the chisel, which is determined by the custom of the surgeon. The place most commonly selected is that recommended by Macewen,[1] on the inner side, a short distance above the tubercle of the adductor tendon. The distance varies with the size of the patient. In children it should be but little above; in older cases, where the width of the bone is to be considered, a point one-half inch above

[1] Brit. Med. Journ., June 30th, 1888, p. 1377.—Lancet, April 21st, 1889.

the tubercle is the point of election. The osteotome is driven into the bone with the blade at right angles to the long axis of the femur, and by successive blows with the mallet the operator cuts nearly through the whole thickness of the bone. The osteotome is likely to become wedged very firmly unless the precaution is taken to move the handle of the chisel laterally after each blow. In this way alone can one cut from the front to the back of the bone, for driving the chisel straight through in one line accomplishes but little. When the chisel has dis-

FIG. 247.—Moderate Knock-knee Before Operation.

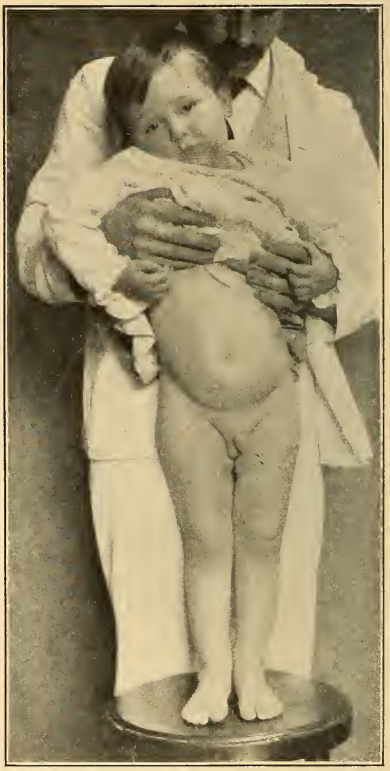


FIG. 248.—Same Case After Macewen Osteotomy.

appeared to a depth indicating that three-quarters of the bone has been divided, it should be withdrawn and an attempt made to fracture the thigh by gentle bending. If this cannot be done, the osteotome should cut further, for the common mistake is a failure to divide the anterior and posterior borders of the femur.

Some skill is required in the use of the osteotome, which is made to serve not only as an instrument for dividing the bone, but as a probe which enables the surgeon to determine what portion of the structure

he is dividing. The bone being in its different parts of different hardness, the resistance varies, and the localization of the part cut is not difficult. As little injury as is possible should be done to the bone, and little is inflicted if the osteotome divide the outer cortex for the width of an inch on the side entered and undermine the cortex of the remaining side, cutting through the spongy portion. The insertion of different sized osteotomes is not necessary. The osteotome should be held firmly and its direction carefully attended to by the surgeon.

When the bone has broken, unnecessary manipulation should be avoided, but the limb should be put in a corrected position after having been overcorrected, and, after an aseptic dressing has been applied, a plaster-of-Paris bandage should be put on to hold the leg in a corrected position. But little pain follows the operation. No change of dressing is needed; the plaster may be removed in three or four weeks, another reapplied, and in six weeks or more the patient allowed to stand on the limbs.

In correcting the deformity it is manifest that in one place a gap is left to be healed by blood clot, and in another place the divided fragments will be pressed firmly together. As the periosteum is but little damaged, firm union takes place, as has been shown clinically in a large number of cases and by pathological specimens of cases dying a year or more after the operation. The operation, when properly performed, is devoid of danger, and non-union need not be anticipated in cases suitable for operation.

Sometimes, when the deformity lies chiefly in the head of the tibia, the operation of osteotomy might be performed there either alone or in connection with femoral osteotomy. The removal of a wedge of bone is rarely necessary from either the femur or tibia in cases of knock-knee.

Much care is needed in the application of the retaining plaster bandage. After the wound has been properly protected by aseptic dressings, the limb should be carefully covered with cotton, not only to allow for shrinking of the tissues, but to prevent undue pressure on any projecting points.

If the limb has been properly corrected, which is essential to the success of the operation, the application of the bandage differs in no way from that employed in the treatment of ordinary fractures. The danger of sloughing under the plaster is not great, but if the surgeon desires to examine the bone a window can be cut in the plaster. The bandage should not be removed or the corrected position interfered with until union takes place.

Osteoclasis.—The forcible fracture of bone by instrumental or manual means in knock-knee is decidedly inferior to osteotomy, inasmuch as it lacks the precision of that method; more splintering occurs, and rupture of the external ligaments and epiphyseal separation are apt to

occur, as in redressement forcé.[1] It is therefore better to limit the use of osteoclasis to the correction of bow-legs, where the instrumental or manual force can be applied to the shaft of a long bone.

BOW-LEGS.

Bow-legs is the name applied to the opposite deformity to knock-knee, which is an outward angular deformity of the knee, or a general

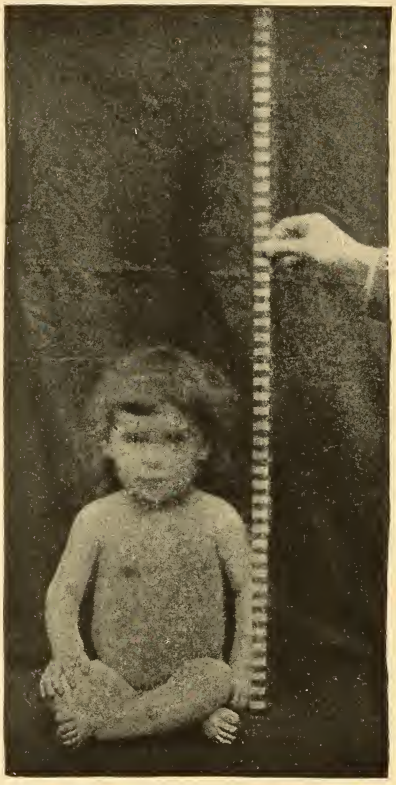


FIG. 249.—Child Sitting Turk Fashion, Producing, at Junction of Lower and Middle Thirds of Legs, Anterior and Lateral Bowing. (Children's Hospital Report.)

FIG. 250.—Child with Bow-legs in Ordinary Sitting Position, Showing Fitting of One Leg to the Other. (Children's Hospital Report.)

outward bowing of the legs, so that when the patient stands erect with the heels together the knees are a greater or less distance apart.

The condition is also known as genu varum, genu extrorsum, out-knee, bowed legs, or bandy legs. In German one speaks of it as Säbel-bein, Sichelbein, O-bein, and in French as Genou en dehors.

It is single or double, generally the latter, and may exceptionally exist in one leg when knock-knee is present in the other.

[1] Codilla: Zeitsch. f. orth. Chir., Bd. xi.

Occurrence.—The deformity is almost always the result of an outward yielding of the long bones of the leg, especially of the tibia. At times, however, it is clearly due to an obliquity at the knee-joint, where the external condyle appears the larger of the two.

The anatomical changes found are those of rickets. The bending of the bones is in most cases, like the other deformities of rickets, a simple yielding, without fracture or destruction of bone tissue.

Causation.—Bow-legs is essentially a rhachitic deformity in children, and true bow-legs can occur only in a child whose bones are soft enough to bend easily. It occurs in the first three or four years of life, and ordinarily in connection with general rickets; sometimes, however, other rhachitic manifestations are absent; but the yielding of the bones in a child of this age must of itself be accounted sufficient evidence of rickets.

Bow-legs of a marked type are seen in children who are too young ever to have borne their weight upon their legs. To account for this, one must assume a lateral pressure from carrying and from the sitting position, along with the possibility of some distortion from tonic muscular pull. Early walking, so much talked about as a cause of bow-legs, is not to be accounted a factor of any importance in their production unless rickets in some degree is present.

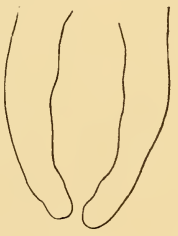


FIG. 251.

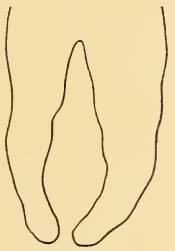


FIG. 252.

FIG. 251.—Bow-legs, Gradual Curve Involving the Whole Leg.

FIG. 252.—Bow-legs, Curve mostly in Tibia.

Why the bones should bend outward as they do is a question which is by no means settled.

The child with rickets stands with thighs flexed and the lumbar spine arched forward; once given this condition, it is easy to see how bow-legs arise. As the thighs flex the knees are separated and the femurs rotate outward on their own axes; as a result of this the line of gravity, instead of falling outside of the knee-joint, as we have seen was the case in the normal erect position, falls inside of it; and any yielding of the bones, of course, must take place in the outward direction. With the yielding of the bones the line of the legs falls farther and farther outside of the line of gravity, and the body weight continually acquires better leverage to bend the bones.

Anterior curvature of the thigh and the leg bones is manifestly the result of body weight coming upon a flexed limb, conjoined perhaps to the action of the most powerful muscles in the body (the flexor muscles of the thigh) pulling in the same direction.

Symptoms are absent, except, of course, those of rickets. But the

deformity is plainly evident, and even in the milder cases the gait is modified in a characteristic way. The child walks with a distinct waddle and generally with the feet wide apart and a tendency to invert the toes. The gait in bad cases bears a resemblance to the waddling gait of double congenital dislocation of the hips. The line of the leg lies so much outside of the line of the centre of gravity that in bearing weight

FIG. 253.—Standing Position of Child with Moderate Bow-Legs.

FIG. 254.—Curve Involving Whole Leg.

on the left leg, for instance, the body must be thrown decidedly over to the left to bring it over its line of support; it is in a measure the reverse of the gait in knock-knee. This lurching is inevitable with each step, and, other things being equal, is in a degree proportionate to the amount of curve present.

The deformity is almost always more conspicuous in the standing position, both because these children stand with the legs so far apart

and because the knee-joints generally yield somewhat in a lateral direction when the body weight is superimposed.

The curve is most often a gradual and uniform bowing of the femur and tibia, so that with the feet together the outline of the legs forms an oval which in severe cases approaches a circle. A second class of cases presents a bowing chiefly in the lower third of the tibia which is more angular in character, and the femurs are practically normal; a third class presents, either alone or in conjunction with the other deformities, a bowing forward of the tibia and sometimes of the femur also. These are the three common types of the deformity. At times

FIG. 255.—Severe Anterior Bow-leg, Seen from the Front and Side. (H. L. Burrell.)

the deformity lies chiefly in the knee-joint and the bones are comparatively straight.

Occasionally the condition of knock-knee and bow-leg existing in the same leg is seen.

An inward rotation of the lower part of the tibia exists in bow-legs which causes "toeing in" in walking. This is apparently a part of the process of side bending, as a three-cornered weight-bearing body like the tibia, in bending to the side, finds less resistance in bending and twisting than it does in bending alone.

Diagnosis.—The condition of bow-legs is evident on inspection. Macewen's definition applied to this deformity would be, that it was a condition in which a line drawn from the head of the femur to the middle of the ankle-joint would fall inside of the centre of the knee-joint.

It is often difficult to determine how much of the deformity lies in the tibia and how much in the femur. If the legs are crossed until the insides of the knees are together when the child is in a sitting position, it will be seen whether the femurs include an oval space between them or are parallel to each other.

FIG. 256.—Anterior Bow-legs.

Prognosis.—The prognosis in outward bow-legs is favorable; in anterior bow-legs, less favorable under expectant or mechanical treatment. The prospect of spontaneous outgrowth of the deformity is better than in knock-knee, and in young children rational mechanical treatment offers almost sure relief. The prognosis of bow-legs, when untreated, will be considered more in detail in speaking of the treatment by expectancy. Operative treatment can ameliorate almost any condition of deformity and often entirely rectify it.

When the deformity is extreme or the bones are eburnated, it is not, of course, likely that the child will outgrow the bow-legs.

Treatment.—The treatment of bow-legs, like that of knock-knee, is to be considered under three heads: I. expectant, II. mechanical, III. operative.

I. The *expectant treatment* is suited to a large percentage of cases of the deformity, and its range of applicability is wider than in knock- knee. The mechanical conditions are not so much in favor of the increase of the deformity as in knock-knee, and the tendency in slight cases is toward rectification in the course of growth. In general, when the curve is uniform, involving femur and tibia alike, the chances are more favorable for spontaneous cure than if the deformity is localized in the tibia and more angular.

During expectant treatment the general condition should be most carefully attended to and rickets treated from the first. The child should be encouraged to be off of his feet as much as possible, and the legs should be massaged and manipulated each night, being gently bent toward a straight direction.

In all cases tracings should be taken at least once each month, to determine if the deformity remains stationary or is improving, and if after two or three months no improvement is evident, mechanical treatment should be begun.

FIG. 257.—Bow-legs Affecting Chiefly Bones of Lower Leg.

II. *Mechanical treatment* is based upon the principle of drawing the knee inward to a rod which has counter-points for sustaining outward pressure at the upper part of the thigh and at the ankle. Here, as in knock-knee, traction from a rigid rod is more definite and more satisfactory than from an elastic one. The form of apparatus used is of little consequence so long as it answers the indications and holds the knee extended (Chapter XXI., **21**). It is no longer customary to treat these cases by recumbency.

The apparatus shown (Chapter XXI., **19**) is the one generally in use at the Children's Hospital in Boston, and is serviceable. It consists of a steel upright, which is attached below to the sole plate of the shoe. It runs up nearly to the origin of the adductor muscles, but it must fall a little short of them or it will excoriate the skin in walking. The upright is then bent forward and upward, and curved to fit into the groin and come up as far as the posterior part of the dorsum of the ilium. In this way a lever is provided with which to evert the feet to any extent by altering the curve of these arms and strap-

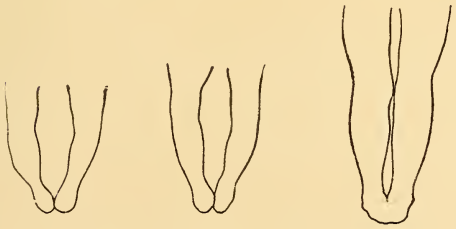


FIG. 258. FIG. 259. FIG. 260.

FIGS. 258, 259, and 260.—Case of Bow-legs. Progress in three years under expectant treatment.

ping them together behind. Pads for the outside of the legs are made of leather and buckled by two or three straps to the upright, opposite the greatest convexity of the curve.

Anterior tibial curves are not susceptible of improvement or cure by mechanical treatment except in slight cases in which the bones are soft. In these cases it is useful to apply to the foot (Chapter XXI., **20**) a modification of the brace described above (Chapter XXI., **19**).

FIG. 261.—Bow-leg. Brace Applied.

The mechanical treatment of bow-legs should be advised in cases in which the deformity is severe or sufficiently obstinate to make it doubtful whether spontaneous outgrowth of the deformity will occur, because braces do no harm and do not retard spontaneous improvement. After the age of three or four it is not generally worth while to begin mechanical treatment.

In the case of babies the expectant plan of treatment is the one to be followed at first.

III. *Operative Treatment.*—**Osteoclasis.**—In the case of bones still soft or in very young children, if it is desired to operate at that stage, manual fracture has a place in the operative treatment, but even then manual fracture presents no advantage over the osteoclasts.

Mechanical fracture is made feasible by the use of osteoclasts, of which the one of Rizzoli is the simplest. The appliance is easily understood from the accompanying illustration. The instrument is made of heavy steel, and the rings and the screw pad all slide on the bar so as to be adjustable to any length of leg. The parts of the apparatus which come in contact with the leg are padded so that the edges shall not cut. The instrument is applied to the bared limb, the rings being adjusted as far as is possible from the point at which fracture is desired. In placing the rings of the osteoclast on the limb, care should be taken not to put them too near to the joints of the ankle or knee, as the epiphyses might be separated by carelessness. The screw is to be adjusted so as to press at the point of election for fracture, which is at the point of the greatest convexity of the curve. Pressure is increased until

fracture of the bones takes place. The fibula generally breaks first, the tibia shortly afterward on continuing the screw pressure. The fracture of the bones is evidenced by a loud snap which can be heard anywhere in the room.

The bone will usually be found to bend before fracture occurs. If the instrument is well padded there will be no danger of injury of the skin from the temporary pressure necessary for fracture, although the amount of this pressure may be very great. The skin will become blanched or congested, but after the removal of the osteoclast the color will be found normal, with but slight evidence of pressure. The fracture will be found to have taken place opposite to the screw-pad plate.

An excellent osteoclast, devised by Dr. R. T. Taylor, of Baltimore, has the advantage of working more rapidly. It is, however, somewhat more elaborate than the Rizzoli and not so easily carried about.

After the bone has been broken, the osteoclast should be removed, the fragments placed with the hand in the desired position, sheet wadding carefully placed around the leg, and the limb fixed in a plaster bandage and held in a carefully corrected position. The bandage

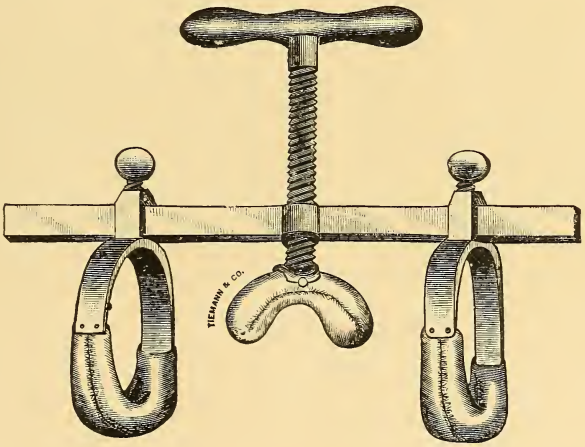


FIG. 262.—Rizzoli's Osteoclast.

should reach from the toes to the hip, and the limb should be held in the corrected position until the plaster has hardened thoroughly. When there is a rotation of the tibia as well as a curvature, care should be taken to see that this also is remedied and that the limb is fixed in a normal position.

Experience has shown that the procedure is ordinarily free from risk, and in properly selected cases the danger of non-union after fracture may be disregarded. The fracture is a transverse one and there is no danger of splintering the bone. A number of experiments upon

the cadaver were made by the writers with reference to this point, and it was found that although splintering will take place in dry bone if subjected to fracture by an osteoclast, yet bone undried, as found in the dissecting-room, will break transversely; the fracture takes place as a sharp linear fracture half-way through the bone. The part of the bone nearest the side of pressure breaks with an irregular line of fracture, as if torn.

The amount of force required for the fracture of an adult bone is very great, so much so as to make osteotomy in most instances a preferable procedure.

Osteoclasis near the joints is difficult, but in the shaft of the tibia the operation is an excellent one, yielding satisfactory results with but little discomfort to the patient.

Cases should not be operated upon unless the bones are fairly

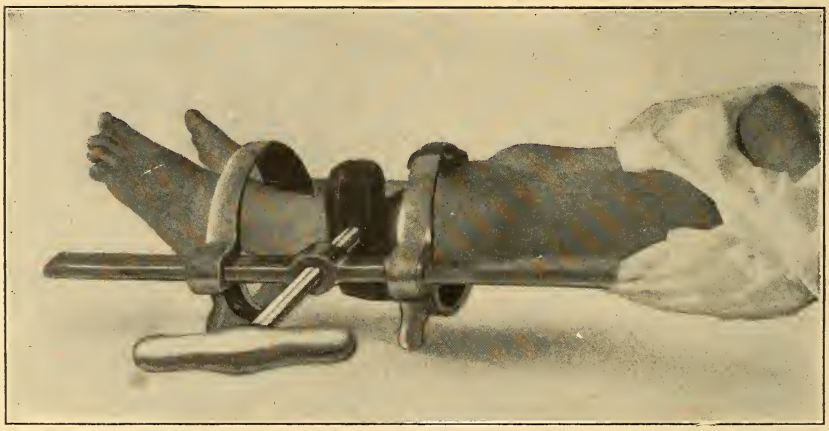


FIG. 263.—Method of Applying Osteoclast.

strong—that is, not if the rhachitic process has not been well arrested, as recurrence of the deformity may take place.

As a rule, the operation should not be performed before the age of four.

The limb should remain in a fixed bandage for four or five weeks, and no appliance is needed as an after-treatment.

Osteotomy should be employed in place of osteoclasis in cases of bow-legs (1) when the curvature is so near the joint that osteoclasis is not practicable; (2) when the bone is so strong that osteoclasis is not feasible; (3) when several curves exist in the same leg; (4) when the curvature is anterior; (5) in cases of bow-leg in which the distortion is largely in the lower epiphysis of the femur; (6) in cases in which it is desired to locate the fracture very accurately, as in badly united fractures of both bones of the leg with displacement.

Osteotomy for bow-legs is a similar operation to that for knock-knee; the division of bone is made wherever it appears most necessary, and no formal operation can be laid down. In young children the fibula need not be cut with the osteotome, but can be broken manually.

Anterior Bow-Legs.—In the treatment of anterior bow-legs, *i.e.*, where the curve is forward and not to the side, the tibia may be broken by the osteoclast applied in the usual way, and after the fracture has been loosened by the hands the leg may be set straight. Tenotomy of the tendo Achillis aids this attempt and is generally necessary. Osteotomy, however, as a rule is more satisfactory in these cases. In anteriorly curved bow-leg in children, a linear osteotomy can be employed dividing the posterior two-thirds of the tibia and using the anterior portion as a hinge with the interlacing broken fibres and uninjured periosteum to promote healing. The osteotome is inserted in the side of the

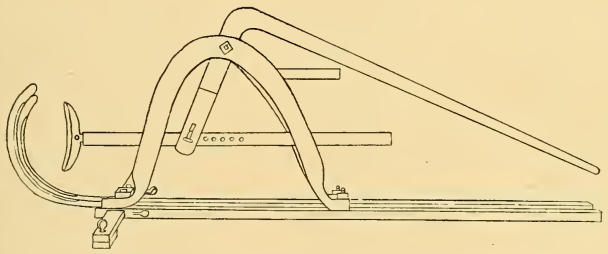


FIG. 264.—The Lever Osteoclast of R. T. Taylor.

tibia. By this procedure the shortening caused by removing a wedge is avoided. Considerable manipulation is necessary after the osteotomy to free the fragments from the shortened posterior tissue which is necessary to give a corrected position. The gap caused will, as in the operation for knock-knee, heal by blood clot. In older cases a wedge-shaped excision may be necessary.

After osteotomy it is not necessary to wire the fragments of bone together; if they are placed in apposition and fixed, union can be expected to take place.

Ultimate Results of Osteotomy and Osteoclasis.—J. E. Goldthwaite traced out twenty-eight cases of knock-knee and bow-legs operated on in the Children's Hospital, not taking into account any case operated within a year and a half of the beginning of his investigation. There were eleven cases of Macewen's osteotomy for knock-knee and eleven of osteoclasis for bow-legs, while there were five cases of anterior bowing of the tibia treated by osteotomy. The average length of time after the operation was four years, and of these cases only one had re-

lapsed. That was a colored boy, four and one-half years old, who presented a condition of extreme rickets. He had both knock-knee and bow-legs, and osteoclasis and osteotomy were done and the knock-knee had recurred somewhat since operation.

Cases will be met when several curves are present, and the judg-

FIG. 265.—Bow-legs of Moderate Degree Before Operation.

FIG. 266.—Same Case After Osteoclasis.

ment of the surgeon will be exercised in a choice of what bone is to be attacked and if more than one shall be operated upon at one time.

In the hands of a surgeon skilled in these operations and working rapidly, several bones may be corrected at one sitting. The surgeon's purpose should be to correct those deformities which most interfere with normal gait, and leave others to the correction of growth.

It may be said that the results in the treatment of these deformities in childhood are exceedingly satisfactory as a rule, the surgeon aiding nature, and nature completing the efforts of the surgeon, so that little or no trace of the previous deformity will remain in after-life. It is not advisable to operate in either bow-legs or knock-knee before the age of four years.

RHACHITIC CURVES IN THE UPPER EXTREMITY.

These rarely present themselves for treatment, and but little further need be said except that by means of osteotomy the curves of the upper extremity can be treated as readily as those of the lower.

IMPROPERLY UNITED FRACTURES.

The same method can be applied in the correction of improperly united fractures of the upper and lower extremities. In this class of affections, however, vicious callus may be present in such a way that more than linear osteotomy may be needed. The principles of treatment for the correction of these curves, in the main, are those considered in the treatment of rhachitic curves.

In deformity following badly united fractures, however, the employment of a narrow osteotome applied freely at such points as may be necessary to weaken the callus will be found useful.

CHAPTER X.

COXA VARA AND COXA VALGA.

Coxa vara and traumatic coxa vara.—Etiology.—Pathology.—Symptoms.—Diagnosis.—Prognosis.—Treatment.—Coxa valga.

It has been demonstrated by Dwight that the normal range of variation in the angle between the neck and the shaft of the femur is much greater than has been ordinarily supposed. When these variations are slight no clinical symptoms follow, but disturbance of the function of the hip is likely to result when this angle is diminished beyond a certain point.

The name *coxa vara* is applied to the condition in which the neck of the femur is bent downward sufficiently to give rise to symptoms. This bending may reach such an extent that the neck forms with the shaft a right angle or less, instead of the normal angle of 120° to 140°.

FIG. 267.—Specimen of Severe Coxa Vara. (Robert Jones.)

ETIOLOGY.

Coxa vara may be unilateral or bilateral, and affects males more often than females. It is, in general, an affection of growing bone, and is seen most often in adolescents, and next most frequently in children,

although adults are not exempt. The more frequent affection of adolescents is explained because the disability is more noticed by them than by children, because the strain coming upon the growing femur is

FIG. 268.—Radiograph of Same Specimen. (Robert Jones.)

greater the larger the individual, and because the neck of the femur is relatively longer in them than in young children.[1] The affection may be congenital.[2]

PATHOLOGY.

The shape of a growing bone is in general determined by the relation between the strain coming upon it and the resistance of its structure. If these relations are normal, the usual shape of the bone will be preserved; if the resistance is diminished or the strain increased, modifications in shape are likely to occur.[3] The causes of coxa vara are, therefore, to be sought in increased strain or diminished resistance in the neck of the femur.

Coxa vara is to be found in connection with rickets, osteomalacia, acute osteomyelitis, and ostitis deformans. The changes resulting from the destructive processes of arthritis deformans and tuberculosis

[1] Whitman: "Orth. Surgery," 2d edition.

[2] Krebel: "Coxa Vara Congenita." Cent. f. Chir., October 17th, 1896.—Joachimsthal: Zeit. f. orth. Chir., xii., 1 and 2, 52.

[3] Frieberg and Taylor: "Wolff's Law." Orth. Trans., vol. xv.

of the hip may cause a changed relation between the head and shaft of the femur, simulating coxa vara.

Coxa vara may exist in cases presenting no clinical or pathological evidence of any condition causing a softening of the bone. In certain marked cases the change in shape may be clearly seen without other evidence of disease.

In addition to the downward displacement of the head and neck of the femur, there is generally also present a yielding of the neck in the horizontal plane. The most common bend of the neck is that with the convexity forward, so that the leg is rotated outward and the foot everted. In other cases, less commonly seen, the neck is bent with the convexity backward, and the foot and leg are inverted. In still other cases the depression of the head and neck in relation to the shaft may be directly downward without forward or backward bending. In these

FIG. 269.—Specimen of Coxa Vara, no Clinical History. (Warren Museum.)

cases neither eversion nor inversion will be marked. The changes may be most evident at the end of the neck of the femur nearest the trochanter or at the end nearest the epiphysis. In exceptional cases there may be bending of the upper part of the shaft of the femur.

Traumatic Coxa Vara.

(Fracture of the neck of the femur, epiphyseal disjunction, infraction of the neck of the femur, Schenkelhalsbrüche, etc.)

Described under these various names is a changed relation between the head of the femur and its shaft, which may be classed with coxa

FIG. 270.—Specimen of Severe Double Coxa Vara from an Adult Female (No. 3821 in the Vienna Pathological Anatomical Museum). (Albert.)

vara of non-traumatic origin. It is clearly traumatic in origin, following slight or severe accidents. It exists chiefly in children and is often overlooked. The pathological change consists most often of a displacement, partial or complete, of the epiphysis downward, and a consequent elevation of the trochanter in relation to the head of the bone. At other times the injury results in a real fracture or infraction of the neck of the femur, the junction of the epiphysis and shaft apparently escaping injury.[1]

[1] Hoffa: Zeitsch. f. orth. Chir., xi., 3, 528 (with bibliography).—Whitman: Am. Journ. Orth. Surgery, ii., 1.

In some instances, while no evidence of trauma is clear, enough strain coming upon the epiphysis to modify the growth of the bone may have existed without giving rise to characteristic symptoms of fracture

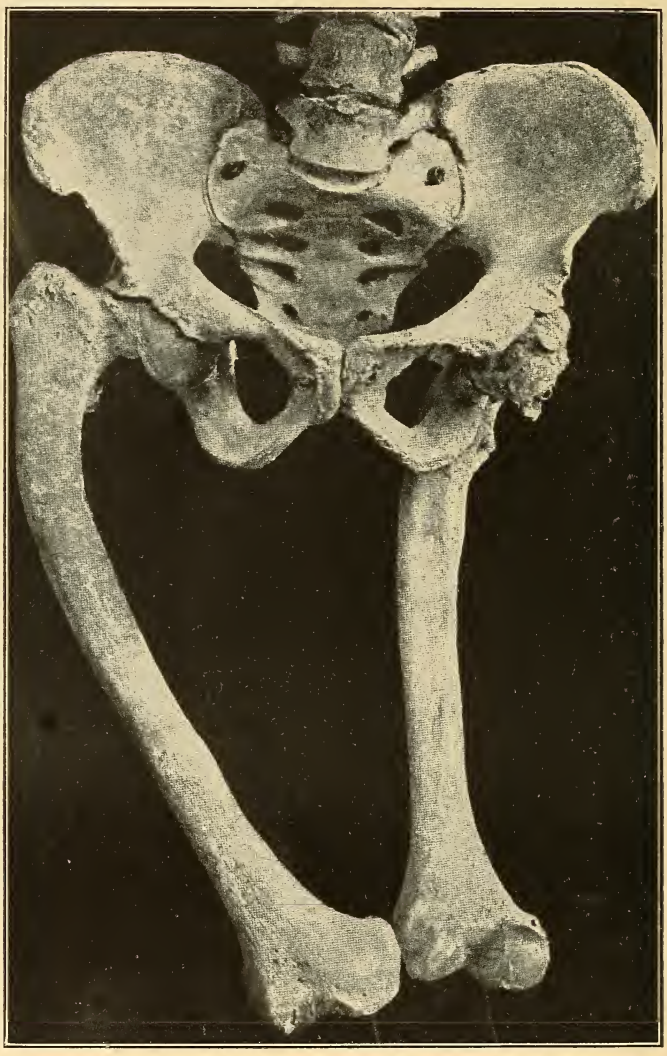


FIG. 271.—Coxa Vara and Bending Outward of the Upper Shaft of the Femur. (Albert.)

or epiphyseal separation. In other cases a fracture of the neck of the femur in adolescents or children, sufficiently severe to necessitate thorough treatment by the usual methods, may be followed months after by yielding of the neck of the bone induced by the softening of the neck incident to callus formation.

SYMPTOMS.

The early development of coxa vara is not likely to be accompanied by marked symptoms, the earliest signs noted being generally referred to the hip-joint, which is the seat of vague discomfort and slight irritability and pain, and walking is avoided. The characteristic symptoms when the deformity is established are as follows:

Shortening exists in unilateral cases and the trochanter is raised above Nélaton's line in both unilateral and bilateral cases. In children

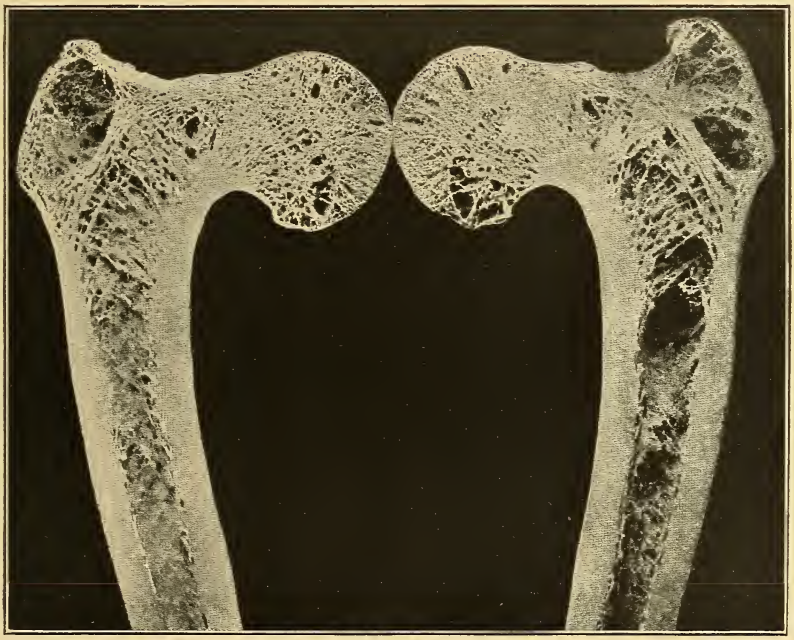


FIG. 272.—Sagittal Section of Coxa Vara, Showing Rearrangement of Trabeculæ to Compensate for Cross Strain. (Abbott.)

the shortening may be slight. The trochanter in marked cases is more prominent than normal.

Limitation of motion of the hip-joint is most marked in the direction of abduction, which is due not only to a shortening of the abductors, but to the pressure of the trochanter against the ilium when the leg is abducted. Joint irritability is generally present and may be severe enough to cause limitation of motion in other directions than abduction.

Lameness and *pain* in the joint after exertion are fairly constant symptoms. If the affection is unilateral, a limp is noticeable; if bilateral, a waddling, restricted gait takes its place.

When a backward twist of the trochanter exists, the foot will be *everted* and flexion of the thigh will be accompanied by *eversion* and

abduction. When a forward twist is present, *inversion* of the foot is found. In severe cases the thighs may be crossed in front of the body in full flexion.

Scoliosis may result in unilateral cases. In bilateral cases the distance between the trochanters will be greater than normal.

DIAGNOSIS.

The recognition of coxa vara is not difficult. The top of the trochanter is higher than normal, being above the line drawn from the anterior superior spine of the ilium to the middle of the tuberosity of the ischium (Nélaton's line). Shortening is present if the affection is unilateral. A femoral twist is recognized by determining on deep palpation the direction of the trochanter relatively to the cross axis of the pelvis when the leg is straight and the patella faces directly forward. The trochanter points forward or backward, according to the existing twist. In marked cases limitation in abduction is present, and in cases in which the hip is strained from inability to bear the strain incident to locomotion, symptoms of joint irritation (*i.e.*, pain and slight stiffness on passive motion) may be present. The diagnosis can be aided by a skiagram.

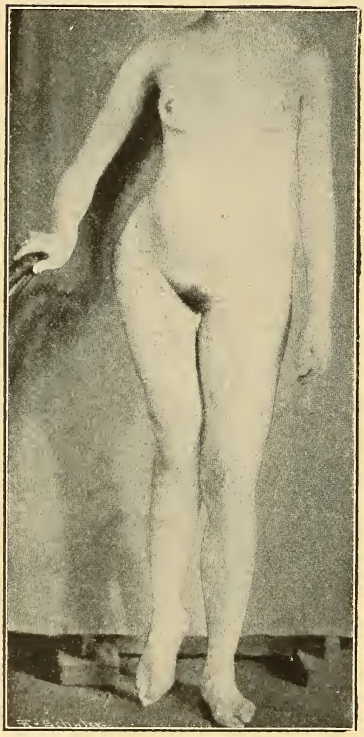


FIG. 273.—Traumatic Coxa Vara of Right Leg, from an Accident Occurring when Patient was Four Years Old. (Hoffa.)

Cases of coxa vara have been regarded as suffering from hip disease and from congenital dislocation of the hip. Such mistakes can be avoided by a thorough examination of the case. In cases of *hip disease* of long duration the joint stiffness is greater than is seen in coxa vara. The stiffness affects all motions, and not chiefly abduction, and the trochanter is not elevated above Nélaton's line, except after considerable bony destruction, which will be accompanied by deep thickening about the joint and by marked muscular spasm. In *congenital dislocation* on deep palpation the head will be discovered outside of the acetabulum. On rotating the limb in congenital dislocation of the hip, the excursion of the head will be greater than that

of the trochanter, the reverse being true in coxa vara. In coxa vara the distance between the trochanters is wider than normal, but this is

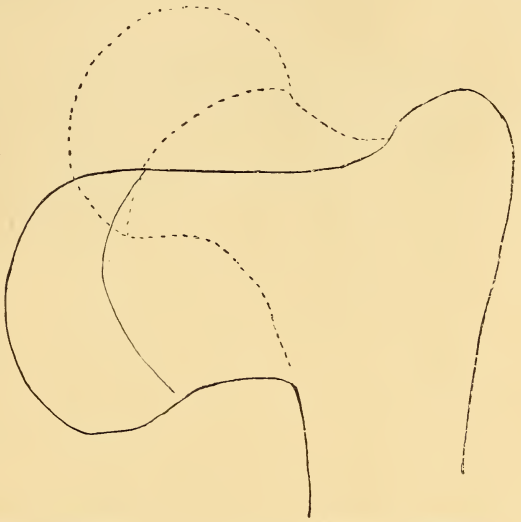


FIG. 274.—Outline of Depressed Neck of Femur in Muller's Specimen. Contrasted with normal (in dotted line). (Whitman.)

not the case in congenital dislocation of the hip. In coxa vara, if the patient stands upon the affected limb and raises the other from the

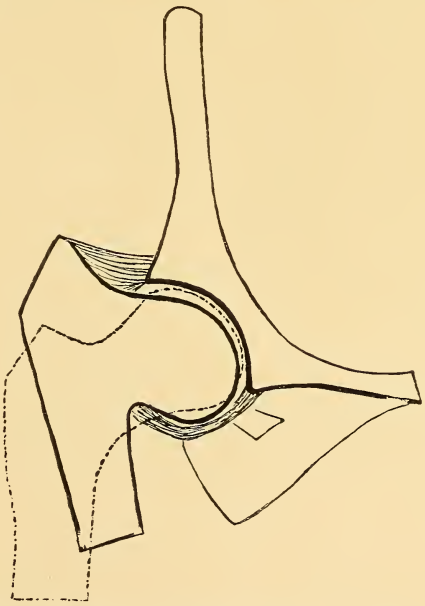


FIG. 275.—Cross Section of Pelvis and Deformed Femur. A scheme to show the effect of the deformity in limited abduction. Dotted outline shows the normal relation. (Whitman.)

floor, the cross axis of the pelvis is held firmly at a right angle with the line of the leg and thigh or somewhat above it, while in congenital dislocation of the hip the pelvis drops.

PROGNOSIS.

In connection with general rickets, when coxa vara exists with other marked rhachitic deformities, the prognosis does not differ from that of knock-knee or bow-legs. In other cases there seems no reason to look for spontaneous cure. Remissions in the symptoms follow the rest necessitated by the joint irritability and may be of considerable duration.

TREATMENT

in coxa vara is either expectant or operative.

Conservative Treatment.—In the stage in which the bone may be regarded as congested and not sufficiently strong to support superimposed weight, crutches or an apparatus which will remove weight

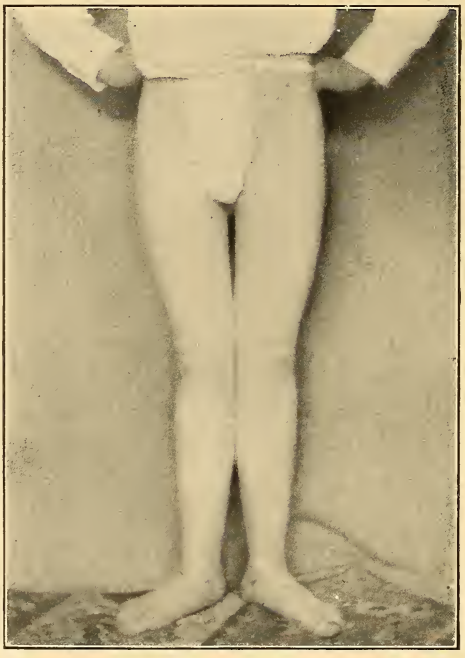


Fig. 276.—Double Coxa Vara Showing Eversion of Feet and Outward Rotation of Legs. (J. E. Goldthwaite.)

from the head and neck of the femur can be employed. A convalescent hip splint (Chapter XXI., **11**) or a Thomas knee splint (Chapter XXI., **14**) can be used in unilateral cases. In bilateral cases hip-trac-

tion splints with an abducted position of the limbs are indicated if the symptoms of joint irritation demand such thorough treatment. Massage is of benefit in stimulating the circulation. When the deformity

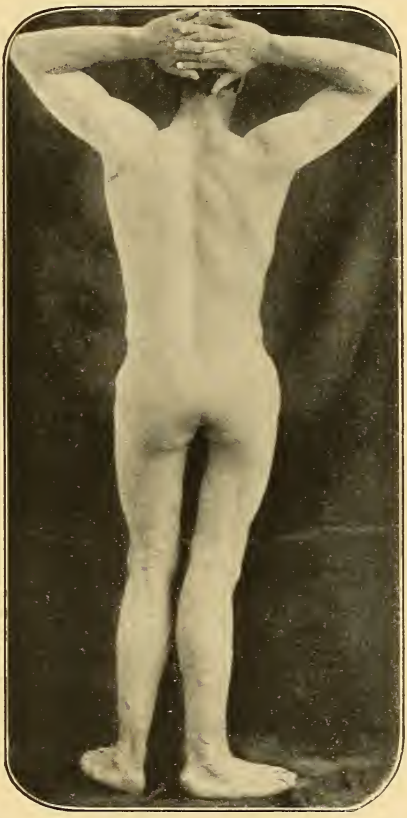


FIG. 277.—Case of Double Coxa Vara. This case was reported by Dr. George H. Monks in the Boston *Medical and Surgical Journal*, November 18, 1886. The photograph here shown is a recent one, having been taken for Dr. Monks three or four years ago.

is slight, such measures may be relied upon not only to check an increase of the deformity and to allay the condition of hip sensitiveness which may follow overstrain, but also to favor correction by a more normal growth.

OPERATIVE TREATMENT.—If the deformity is sufficiently severe to occasion disability, operative measures are indicated. These may be directed to restoring to the patient free motion in the direction of abduction or to the correction of deformity.

Forced abduction may suffice in young children and can be accomplished by abduction of the limb under anæsthesia with or without fasciotomy, and fixing of the limb for a month or more by a plaster spica

bandage in an abducted position. After this, massage and stretching exercises should be prescribed. Protected use should then be resumed.

Osteotomy can be either linear or cuneiform. In *linear osteotomy* the bone is divided by an osteotome, cutting across the femur below the trochanter minor, as described in hip disease. The limb is strongly abducted, the shaft being rotated in or out to correct the twist of the neck. Plaster fixation with the limb abducted should be maintained for from four to six weeks. In linear osteotomy a surgeon familiar with the procedure can divide the shaft as in osteotomy for knock-knee without a skin incision, using the osteotome to divide the skin. Linear osteotomy requires the exercise of some skill in its performance, with the expectation of an excellent result. After this, if the limb is brought into the straight position, the former depressed angle of the neck will be changed to a normal oblique inclination. The bone gap caused by

FIG. 278.—Fracture of Hip Four Years after the Accident. Shows eversion. (Whitman.)

FIG. 279.—Fracture of Hip. Projection and elevation of trochanter. (Whitman.)

the rectification will, as is observed in Macewen's operation for knock-knee, fill by healing by blood clot and subsequent ossification.

The advantage claimed for *cuneiform osteotomy*, or the removal of a wedge-shaped fragment from the femur just below the level of the lesser trochanter, is the certainty of a sufficient gap of bone to correct the deformity. The disadvantage is that the operation requires more dissection and destruction of tissue and causes shortening.

In *cuneiform osteotomy* a three-inch incision is made on the outer side of the femur, from the top of the great trochanter down. The tissues are separated, and by means of an osteotome a wedge-shaped sec-

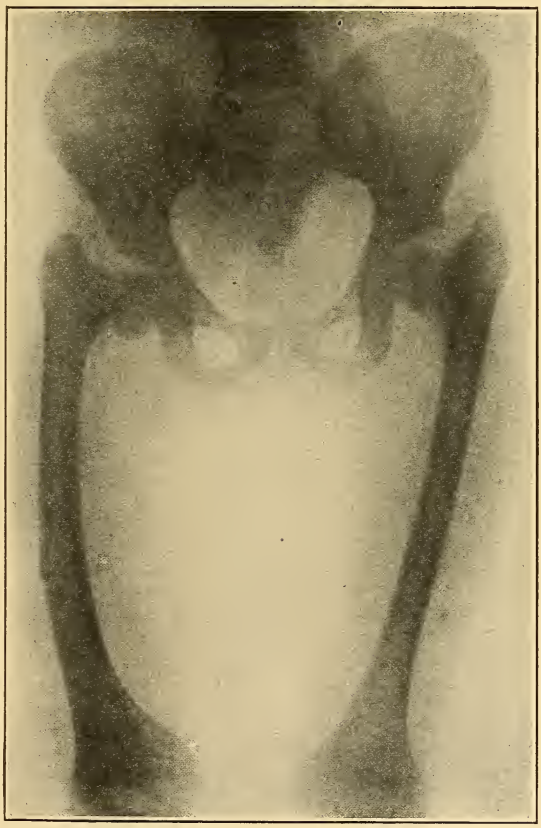


FIG. 280.—Radiograph of a Severe Rhachitic Coxa Vara in a Patient Six Years Old. (Joachimsthal.)

tion of the femur is removed. The apex of the section should be at the cortex of the femur opposite the lesser trochanter, which should not be divided. The upper section of the bone should be at right angles with the axis of the shaft and the lower section made at an angle, the base

of the wedge being three-quarters of an inch wide, the exact amount varying with the size of the bone. After the section has been made and the wedge of bone removed, the uncut inner surface of the femur is broken. The splintered fragment and the periosteum act as a hinge and no wire sutures are needed, the cut bone surfaces being placed in apposition, the top of the great trochanter being pressed against the ilium by abducting the limb. The limb should be fixed in a plaster spica bandage, holding the pelvis and femur securely.

After-Treatment.—After the removal of the plaster bandage the motion of the limb should be encouraged without weight bearing by passive movements, massage, and going about on crutches. After this it is a matter of judgment in each case whether the patient may be allowed unrestricted activity or whether the neck of the femur may still possess too little resistance, in which case a protection splint should be worn.

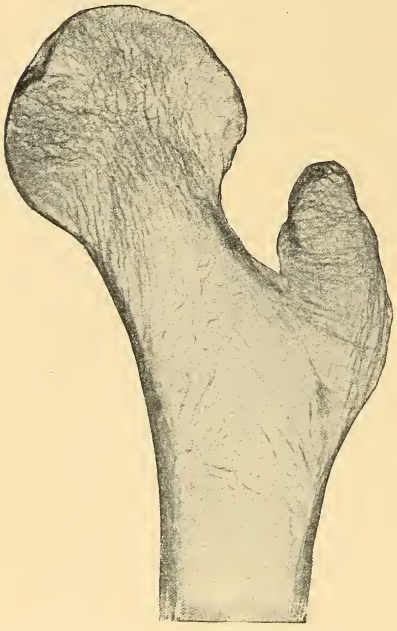


FIG. 281.—Radiograph of a Sagittal Section of a Specimen of Coxa Valga, Amputation of the Thigh having been Done in Childhood. (Turner.)

Traumatic Coxa Vara.—In cases seen long after the accident the treatment does not differ from that described for ordinary coxa vara. In recent cases, seen so soon after the accident that consolidation has had no time to occur, the leg should be abducted and fixed in that position by a plaster-of-Paris spica. Traction may be required in exceptional cases. Unprotected use of such a leg should not be allowed for a year after the injury.

COXA VALGA.

Coxa valga is the name applied to the condition which is the reverse of coxa vara. In this the angle between the neck and shaft of the femur is increased above 140°. In connection with this deformity also twists of the neck of the femur may occur. It has been recorded as occurring in connection with infantile paralysis, in connection with atrophy following old ankylosis of the knee-joint, in osteomyelitis of the pelvic bones, in severe rickets, and in osteomalacia.[1] It has been recorded following

[1] Turner: Zeitsch. f. orth. Chir., xiii., 11.—Albert: "Coxa Vara und Valga," Wien, 1899.

a severe fracture of the lower end of the femur and knee-joint. A congenital case[1] has been reported of double coxa valga in which apparently neither rickets nor trauma was present as an antecedent cause. When symptoms have been reported they consist of an ab-

FIG. 282.—Radiograph of a Case of Coxa Valga. (David.)

ducted position of the leg with eversion, and adduction and inward rotation are limited. The gait is not unlike that in double coxa vara. A satisfactory treatment of the condition has not been formulated.

[1] David: Zeitsch. f. orth. Chir., xiii., ii. and iii., 360 (with literature).

CHAPTER XI.

LATERAL CURVATURE OF THE SPINE.

Definition.—Frequency.— Sex.—Age. — Pathology.—Etiology.—Symptoms.—Diagnosis.—Methods of record.—Prognosis.—Preventive measures.—Treatment.

DEFINITION.

By this term is understood a constant deviation of the spinal column, or a portion of it, to either side of the median line of the body, with a resulting distortion of the trunk. The affection has also been called scoliosis and rotary lateral curvature.

In French it is known as *Scoliose, déviation latérale de la taille*, and in German it is called *Seitliche Rückgratsverkrümmung*, and *Kyphoscoliose*.

Lateral curvature is either congenital or acquired. The former variety, however, is rare; when present, it is a result of imperfect or defective development.[1]

FREQUENCY.

The affection is a common one, but its prevalence can only be estimated, as statistics gathered vary apparently according to the standard of the observer.

Drachmann reports scoliosis in 1⅓ per cent of 28,125 school children in Norway, while in Switzerland[2] 24.6 per cent among 2,314 school children are reported to have had lateral curvature, in Moscow 29 per cent of scoliotics among 1,664 children were found by Hagemann, and in St. Petersburg 26 per cent among 2,333 by Kohlbach.

Berend reports 900 scoliotic patients in 3,000 patients; Langgaard 700 in 1,000 cases; Schilling, 600 in 1,000 (Schreiber). Whitman reports that scoliosis was, next to bow-legs, the most common deformity at the out-patient department of the New York Hospital for Ruptured and Crippled Children.

The distortion is seen more frequently in girls than in boys, but statistics as to the comparative frequency of the deformity in females as compared with males vary. It is placed by different observers at from seven to four females to one male.

[1] Vogt: "Moderne Orthopädik," p. 75.—Schreiber: "Orthopädische Chirurgie," p. 118.

[2] Annales Suisse d'Hygiène Scolaire, 1901.

It is possible that if parents were as solicitous as to slight variations in the figures of their boys as of their girls, the statistics would show a greater proportion among boys than has been reported. In the lateral curvatures of young children (under five), the males are said to equal or to outnumber the females. When school children are observed, the proportion of males is very much greater than when the statistics are taken from patients coming for treatment. Some of the most severe forms are to be seen among males.

Age.—Although it is probable that the distortion exists to a slight extent at an earlier age, the majority of cases brought to the surgeon for treatment are from ten to sixteen years of age. Whitman reports 39 per cent under fourteen years of age, 48 per cent between fourteen and twenty-one; Eulenberg, over 50 per cent between seven and ten years of age, and 10 per cent between ten and fourteen.

Lateral curvature, an abnormality in the shape of the trunk by which its symmetry is lost, is characterized by a curve and twist of the spinal column, causing an undue prominence of one side and other irregularities of contour.

The deformity is more readily understood if the pathological changes are examined.

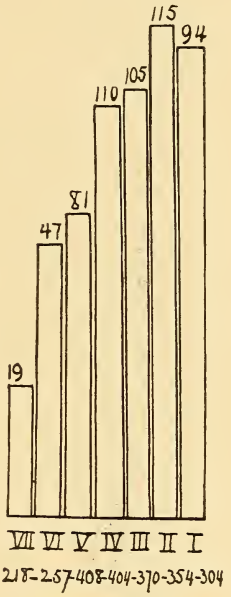


FIG. 283.—Diagram showing the Progressive Increase of Scoliosis during School Life. The lowest grade in school is placed on the left. The lower figure shows the number of children investigated in each grade and the figure at the top the number of scolioses found in each grade. (Scholder.)

PATHOLOGY.

The pathological changes in true lateral curvature are not those resulting from destructive disease of the vertebræ, but are the alterations of bone induced by abnormal pressure and strain.

The spinal column, as a whole, is bent and twisted, and the individual vertebræ are in places altered in shape as well as misplaced from their normal relation to the vertical plane of the trunk. The ribs and pelvis may be altered in shape. The muscles and ligaments are altered in their tonicity and length, and internal organs may be displaced.

Characteristic of the deformity is the combination of a side curve of the spinal column with a twist, the spinous processes as a rule pointing away from and the vertebral bodies being turned toward the convexity of the curve. This rotation is the result of the structure of the spinal column, which cannot bend to the side without twisting.

The changes seen necessarily vary according to the stage of the affection and the degree to which the deformity has developed.

In the earliest stage of scoliosis slight if any anatomical change will

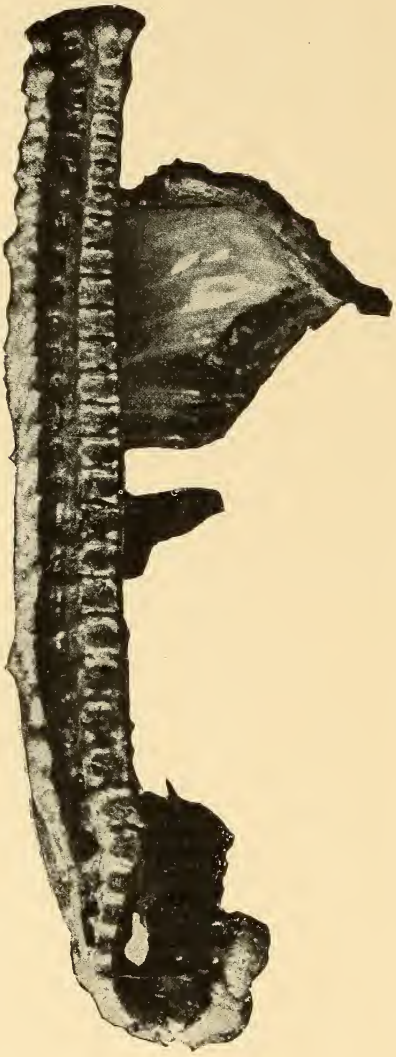


FIG. 284.—Longitudinal Section of the Vertebral Column of a New-born Child, Showing the Absence of Physiological Curves. (Schulthess.)

FIG. 285.—Side View of the Vertebral Column of an Adult Man. (Schulthess.)

be found in the bones, ligaments, or muscles; but in the stage of fixed curves and in the latest phases of the affection, marked distortion of

the whole spinal column, as well as the individual vertebræ, is to be observed.

Wherever a side curve with rotation of the spine has taken place, the bodies are crowded together on the concave and separated on the convex side of the curve. Growing bone adapts itself to altered pressure, and in time the vertebral bodies will be found thicker on one side than the other, and changes in shape of the articulating and transverse processes will also take place. The transverse processes are out of the normal plane; the ribs follow the transverse processes, and show a characteristic projection on one side and flattening on the other.

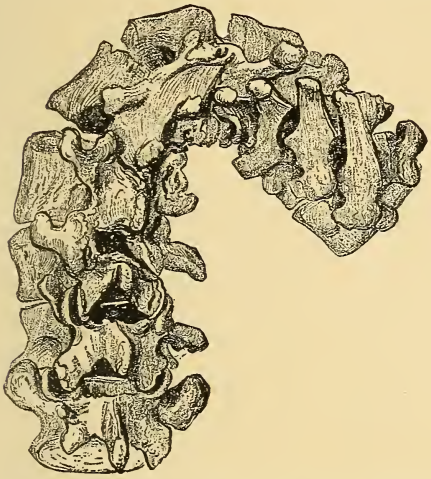


FIG. 286.—Torsion in Lateral Curvature. (Schreiber.)

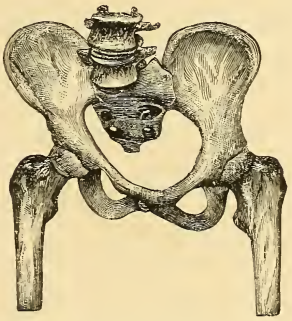


FIG. 287.—Distorted Pelvis in Lateral Curvature.

If the column is curved laterally in two or three directions, rotation necessarily takes place in different parts of it in opposite directions. The projection of the ribs is naturally more noticeable than the projection of the transverse processes without ribs, so that in the lumbar region the rotation seems slight when compared with that of the dorsal region.

The intervertebral cartilages necessarily twist with the vertebræ and are compressed on one side more than on the other in cases of marked curves; in severe cases they will be found on measurement thicker on the side of convexity than of concavity, so that instead of being flat they are wedge-shaped from side to side. In some cases the rotation is more marked than the curve, the line of the spines being nearly straight, while the bodies are found badly out of line, the axis of rotation being near the spines.

Wolff's Law.—The adaptation of bone to pressure has been formulated in what is known as Wolff's law, which is as follows: "Every change in the formation and function of the bones, or of their function

alone, is followed by certain different changes in their internal architecture and equally definite secondary alterations of their external conformation in accordance with mathematical laws."

The relation of bone structure to strain, however, was understood and described by Sir Charles Bell in his treatise on "Animal Mechanics," and was also described by Jeffries Wyman, of Cambridge.[1]

FIG. 288.—Method Used for Producing Deformity of Head by Flat-Head Indians. (From Sketch from Lewis and Clark.)

FIG. 289. — The Flat-Head Indian. An old man.

There is necessarily a torsion of the spinal column whenever it is bent toward the side, and when a curved condition of the spine becomes habitual or constant the changed pressure in the spinal column produces in time alterations in the shape of the vertebral bodies and in the articulating surfaces.

It has been shown that not only do the bodies of the vertebræ give evidence of torsion around the axis of the spinal column, but there is, in advanced cases, evidence of torsion of the bodies themselves in oblique and spiral longitudinal striations on the bodies in the place of

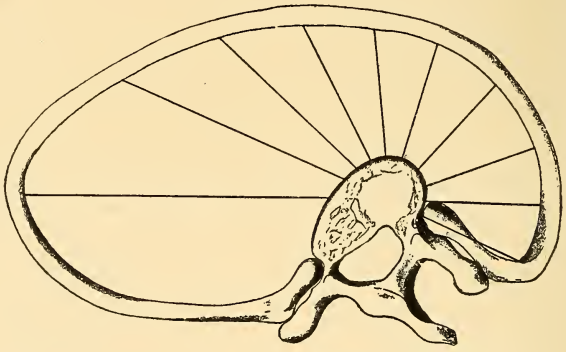


FIG. 290.—Transverse Section of a Scoliotic Thorax. (Albert.)

the usual vertical marking, and in a twist of the spinous process and lamina in its relation to the vertebral body.[2] The bodies lose their nor-

[1] "Animal Mechanics," by Sir Charles Bell and Jeffries Wyman, Cambridge, 1902.

[2] Lorenz: "Scoliosis," Wien.

mal symmetrical shape; the spinal canal becomes irregularly oval in shape, and the transverse and articular processes are altered according to the position of the vertebræ; those on the crowded side being broader and lower than on the convex side. The changed vertebræ vary according to their relative position in the curve and to the direction in which they receive the superincumbent pressure, those at the site of the greatest curve changing the most.

On section the structure of the bones will be found normal, except that abnormalities in bone density and in the trabeculæ will be observed, and irregularities in shape and growth.

The ribs are not only displaced, but altered in shape. They are

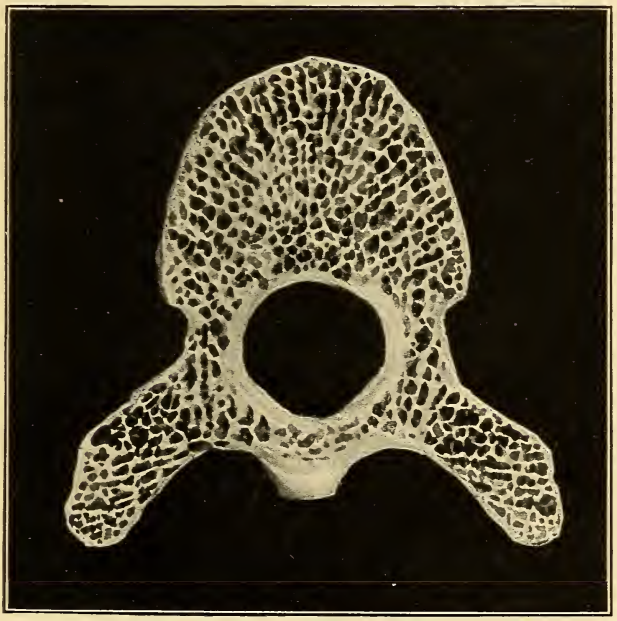


FIG. 291.—Horizontal Section of a Normal Dorsal Vertebra. (Dolega.)

also altered in the line of their obliquity, being lowered on the side of the concavity of the curve.

The contour of the thorax is changed from the altered shape of the ribs; the clavicles remain, as a rule, unchanged, but the tip of the sternum may be deflected from the median line. The ribs project backward at the angle on the side of the convexity of the curve and forward on the side of the concavity.

A cross section of the thorax shows an alteration of the diagonal axes of the chest, and in the ordinary dorsal right convex curve the diagonal axis from the left front side to the right back side of the thorax is longer than on the other side. The different halves of the thorax,

on cross section, should be symmetrical normally, but in lateral curvature the portion on the convex side is smaller than that on the concave side, owing to the flattening of the ribs. The vertebral bodies are also crowded into this half of the thorax, so that there is less room

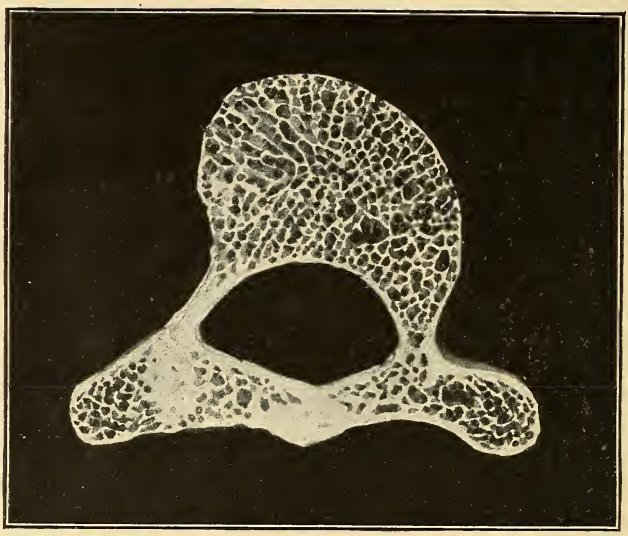


FIG. 292.—Section of the Ninth Dorsal Vertebra in a Case of Right Dorsal Scoliosis. (Dolega.)

for expansion of the lung on that side than on the other side. In the severest cases of distortion, the lower ribs on one side may rest upon the crest of the ilium or sink into the pelvic cavity.

The muscles of the spinal column in an early case of lateral curvature are unaffected, except in cases of a purely paralytic nature. In dissections of advanced cases the muscles are found to have degenerated. The muscles in the concavity of the curve are found neither prominent nor rigid. The prominence and rigidity of the spinal muscles in the lumbar region frequently seen on the convex side of the lumbar curve often convey to the touch a doubtful sense of fluctuation, and have sometimes led to the suspicion of an abscess.

In advanced cases of lateral curvature, the ligaments on the concave side of the spinal column are shortened and those on the convex side are elongated. This is the result of adaptive shortening, and is not found in the early stages of the affection.

Distortion of the Pelvis in Cases of Lateral Curvature of the Spine.—The pelvis is not necessarily distorted in lateral curvature of the spine, but the bones of the pelvis may, if not sufficiently unyielding in their structure, become altered by abnormal pressure or strain. The pelvis may assume the appearance of obliquity from a prominence of one hip due to the uncovering of the crest of the ilium by the over-pro-

jecting ribs, but true obliquity is exceptional. When there is irregularity in the length of the legs, obliquity of the pelvis necessarily exists. The spinal cord is not affected by lateral curvature. The spinal nerves, in consequence of the large size of the foramina, are not liable to suffer compression, but symptoms of nerve-root pressure are at times observed in advanced cases.

Influence of Lateral Curvature in Causing Displacement of Abdominal Viscera.—The abdominal viscera are less likely to be displaced, even in severe cases, than the thoracic organs, though the liver may be out of place and altered in form, according to the direction and extent of the spinal distortion. The spleen may suffer some compression, and the aorta is necessarily displaced. The lung on the convexity of the curve is much more compressed and flattened, and the thoracic cavity on the concavity of the curve is always found to be much larger

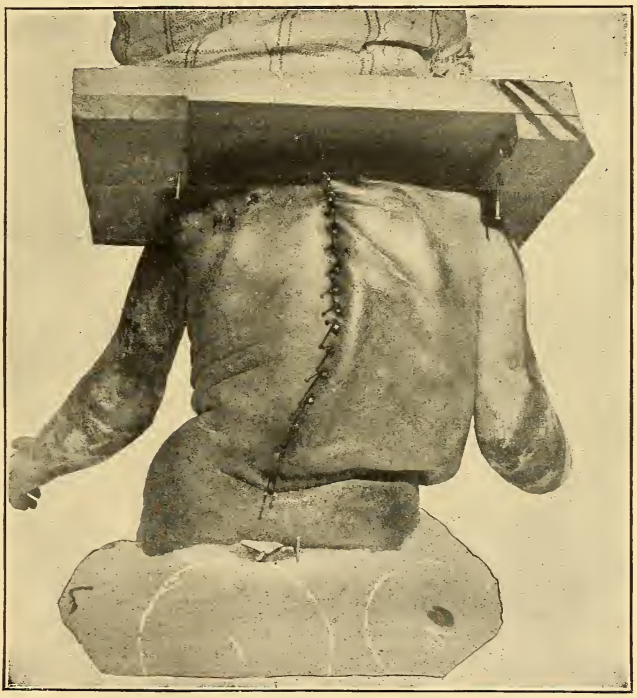


FIG. 293.—Experiment on Cadaver Showing the Causation of a Right Curve with Rotation from Oblique Superincumbent Weight.

than would be expected. The lung on the concavity of the curve may be altered in form, but is not diminished in bulk as on the side of convexity. The heart is generally found displaced toward the concavity of the curve in severe cases.

ETIOLOGY.

When bone was regarded as a structure which was unchanged in shape except by accident or destructive disease, the phenomena of lateral curvature were not easily understood. No evidence of disease or traumatism is found, and, although the bones are abnormal in shape, they are not defective. It is now known that bone, like other portions of the human frame, muscle, and skin, is a structure which adapts itself to conditions, being changed in shape and strength under pressure and strain. Bone can be deformed by abnormal pressure without injury to the health, as is shown by the flat-headed Indians, whose skulls were shown by Clark to have been distorted by pressure mechanically applied for a long period in infancy. The foot of a Chinese lady is another illustration. The shape of the bone, as is well known, alters in different occupations. These alterations in bone, studied as they have been by Bell, Wyman, and Wolff, may be regarded as the result of altered conditions.

The phenomena of lateral curvature, curve and rotation, have been produced experimentally on the cadaver of infants (Bradford and Lovett, 1st and 2d eds., Chapter "Lateral Curvature"), and in animals by Wullstein,[1] who produced scoliosis by securing for six months the spine of a growing dog by a stiff bandage in a bent position. Growing children, obliged to retain an abnormal position through paralysis, often acquire scoliosis, and the Siamese twins, prevented from normal attitudes, developed similar deformities. It is not necessary to seek for remote causes in studying the etiology of scoliosis.

To explain the development of scoliosis it is only necessary to assume the existence of a constantly applied force exerted upon the spinal column in abnormal directions. As the resistance offered by the bone differs in different portions of the spine, a certain type of deformity results from abnormally applied superimposed weight, and, as individuals differ, similar conditions do not produce the same deformity in different individuals. Whatever favors abnormal distribution of the superimposed weight favors the development of the deformity, as is also true of conditions which diminish the resistance of bone. Of the factors favoring abnormal distribution of superimposed weight, the following may be mentioned:

1. Faulty attitudes in standing or sitting.
2. Inequality of the length of the limbs or other causes tilting or twisting the pelvis.
3. Occupations which produce faulty attitudes.
4. Paralysis or weakness of the muscles of the back.
5. Congenital defects, absence or defects of the ribs or vertebræ.

[1] Wullstein: "Die Skoliose," Stuttgart, 1902.

6. Torticollis or inequality of vision in the eyes.
7. Contraction of the chest following empyema.
8. Sacro-iliac disease.
9. Asymmetry of the pelvis.

Lateral curvature is also favored by causes which will diminish the resistance of bone to abnormally applied weight. Apart from disease of the structure of bone, these are: (1) rickets and osteomalacia; (2) abnormal lack of bone resistance of the spinal column, from rapid, excessive, or ill-nurtured growth.

SYMPTOMS.

Early History.—The deformity of scoliosis is developed during the growing years, becoming arrested, as a rule, at the end of the period of growth.

The affection is ordinarily discovered by the patient's mother at the age just previous to puberty, although it is developed earlier than this in a majority of cases without being recognized. The symptoms are so slight in the earliest stages and the deformity is so easily overlooked that the surgeon is rarely consulted. The patient suffers no inconvenience at this stage, and as the child is at an age (five to ten) when the figure is not carefully scrutinized, little attention is paid to the slight elevation of the shoulder or projection of the hip. Upon superficial examination but little else is to be seen, and these symptoms disappear on recumbency or suspension. A careful examination often discloses a peculiarity in standing or sitting.

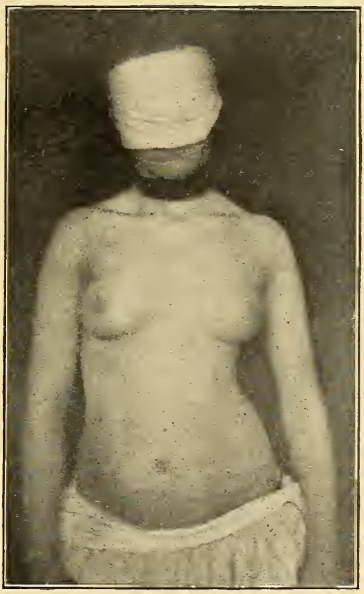


FIG. 294.—Front View of Lateral Curvature, Showing Prominence of Left Mamma in Right Dorsal Convex Curvature.

In a majority of cases when the surgeon is consulted, well-marked development of the distortion has already taken place, with more or less structural change.

The muscular system may or may not be well developed, but in a majority of cases the muscles are not large or strong. In the early periods of the development of the affection there is rarely any symptom complained of except the annoyance of the curvature, due to a distortion of the figure. In a few instances

of growing girls with marked impairment of strength some thoracic pain may be felt, and fatigue on exertion in walking or standing. The period during which the curvature of the spine may develop is indefinite, as well as are the rate and extent of the development. It is impossible, in the present stage of our knowledge, to predict the amount of increase or the permanency of arrest. The liability to increase is greatest during the growing years. But cases of severe curvatures will be seen in which development has slowly continued during the years of younger adult life.

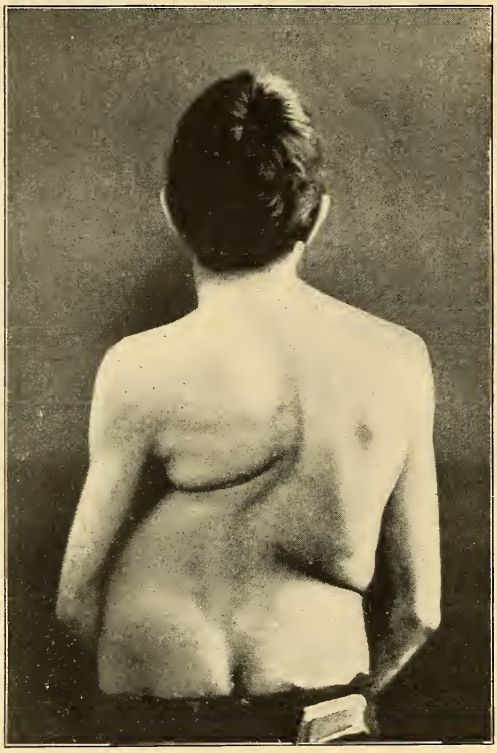


FIG. 295.—Right Lateral Curvature. (Weigel.)

While it is certainly true that the time when a curve may be regarded as arrested is not easily recognized, an examination of a large number of untreated cases justifies an opinion that spontaneous arrest takes place in a very large number of the slighter cases, without further development of the deformity. Even in many of the severer types of the deformity patients will be observed who go through adult life without any increase of, or inconvenience from, the deformity.

The symptoms of lateral curvature are *pain, impairment of general condition*, and *deformity*.

Pain.—Painful symptoms are not common in the affection, except in the severest cases.

The symptoms of pain are of three classes:

1st. Those due directly to the altered muscular or ligamentous strain.

2d. Those due to the abnormal pressure from distorted ribs upon the nerves or ilium, or by vertebræ upon nerves, or to alteration of the size and shape of the thorax, and displacement of viscera.

3d. Neurasthenic symptoms from a lack of vitality, superinduced by the limitations as to exercise and activity, consequent on the deform-

ity, and to the impairment of circulation and respiration by the deformity of the chest.

Impairment of General Condition.—Interruption in the functions of the liver, stomach, and intestines is occasionally seen in severe cases. Shortness of breath also occurs, as well as pain in the stomach, loss of appetite, and indigestion. In the severest cases a lack of deposit of fat in the subcutaneous tissue will be noticed, and the patients are thin, even though they may be in relatively good health.

Deformity.—The chief symptom of lateral curvature is the distortion. This, as has been explained, is not limited to a simple lateral

FIG. 296.—Severe Lateral Curvature (Untreated).

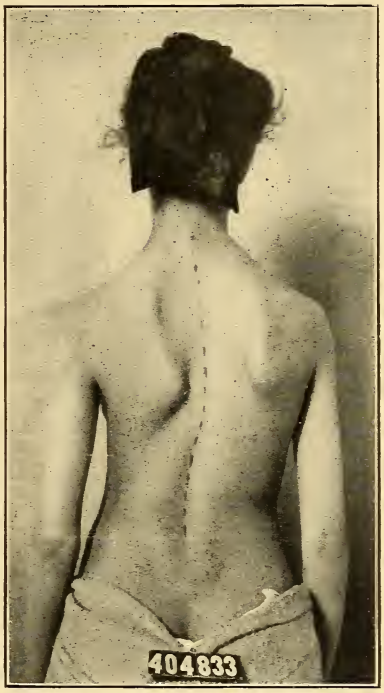


FIG. 297.—Right Dorsal, Slight Left Lumbar Curve.

curvature of the spine, but to this is added a twisting of the trunk; or, in other words, there is both a curvature and a rotation on a vertical axis.

The curves of the spinal column vary in degree, situation, and extent. There are, however, common types, which it is convenient to bear in mind in considering the subject of treatment.

Lateral curvature either involves the whole spine in one curve, termed by some writers *total scoliosis*, or it is chiefly confined to a region or regions of the spine, and the curvature is called *cervical*, *dorsal*,

or *lumbar scoliosis*. These are defined right or left, according to the direction of the convexity of the curves.

What is termed *double scoliosis* is met when an upper curve is found in one direction and a lower in the opposite.

If one lateral curve occurs in the middle region of the spinal column, one or two other compensating curves are of necessity developed in opposite directions, to preserve the patient's balance, above or below the deformity, in order that the head be kept erect and in the median line. These compensating curves may or may not be of pathological significance. In some instances one of the compensating curves is of an equal prominence with the so-called primary curve; in which case the spinal column will present the S-shaped curve which is characteristic. In other cases what is termed the compensating curve may become more marked.

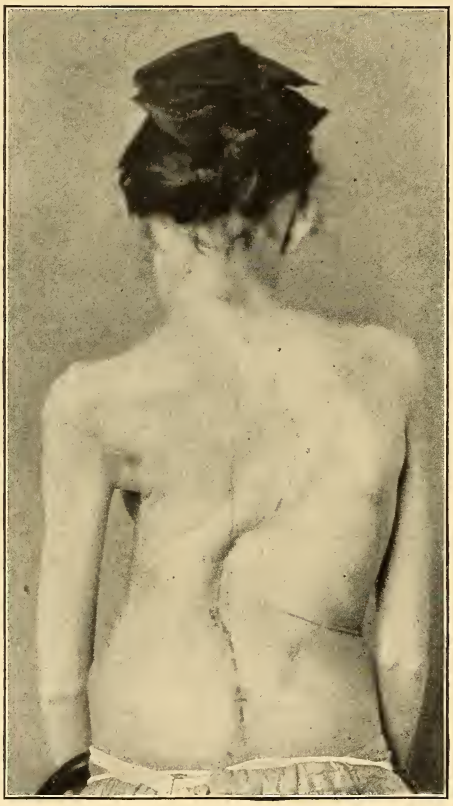


FIG. 298.—Severe Right Dorsal, Left Lumbar Curve Showing Marked Lumbar Rotation on the Left.

The curves are rarely limited exactly to definite portions of the spinal column; the upper curve may be so long as to include all of the dorsal and upper lumbar vertebræ. Again, the lower curve may be so long as to invade nearly the whole of the dorsal region, the compensation taking place in the upper part of the cervical region.

In all varieties of curves except the total, compensating curves, so called, are necessarily present. They may be so slight as not to attract attention.

Furthermore, when the curves are in the flexible stage it is difficult to determine which is the more important one; but after osseous changes have taken place, the most important curves become fixed, and these are the curves which demand most attention. This is partly due to the attitude in which the column is placed, and partly, probably, to a lack of resistance of tissues of certain parts of the spinal column.

Cervical Curvature.—The cervical or cervico-dorsal curves are the least common form of lateral curvature, except when associated with torticollis.

This curvature may, however, occur primarily; when it does, it is most commonly accompanied by a long compensatory lower curve. There is invariably elevation of one shoulder and an inclination of the axis of the head to the side of the concavity of the cervical curve.

Dorsal Curvature.—The most common dorsal curve is with the convexity to the right. In these cases the right shoulder will be raised, the right shoulder blade will project backward more prominently than the left, and will be at a higher horizontal level and farther from the median line of the trunk. The back, just below the scapula, will be more rounded backward on the right side and more flattened on the left, and the left shoulder will be held down. In front, in well-marked cases, the breast and front of the chest may be more prominent on the left than on the right side.

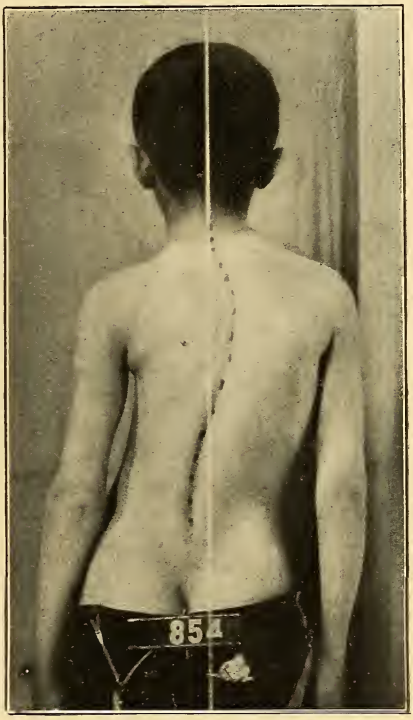


FIG. 299.—Right Dorsal, Left Lumbar Curve with Displacement of Body to the Right.

In addition to the curve there may be a tendency to displacement of the whole trunk to the right side. When this is the case, the right arm, when hanging, will be free from the side, while the left arm, when hanging down, necessarily strikes the hip.

There is also, unavoidably, a change in the outline of the sides of the back. The sides, instead of being symmetrical, as seen from the back, will be different; one side of the outline will be unnaturally straight, and the other more than normally hollowed.

The normal backward physiological curve in the dorsal region may be diminished so that the upper back is abnormally flat, or it may be increased so that the dorsal region is abnormally bowed. The latter condition is spoken of by German writers as kyphoskoliose.

Lumbar Curvature.—Lumbar dorsal or lumbar curvature manifests itself by a prominence of one of the hips; the one on the side of the concavity of the curve appears in the contour of the trunk higher than

on the other side, as it is less covered by overlying tissue. It is often termed a "high hip," but incorrectly; measurement shows no difference. In well-marked lumbar curvature there is also a fulness in the back on the one side, above the crest of the ilium, and a corresponding flattening on the other. In front the umbilicus is at the side of the median line. A marked difference in the outlines of the two sides of the back, already mentioned, is seen in this form of curvature.

A combination of lumbar and dorsal curves in opposite directions, or compound curves as they have been termed, will present the features of both varieties, but the distortion of the most pronounced curve predominates.

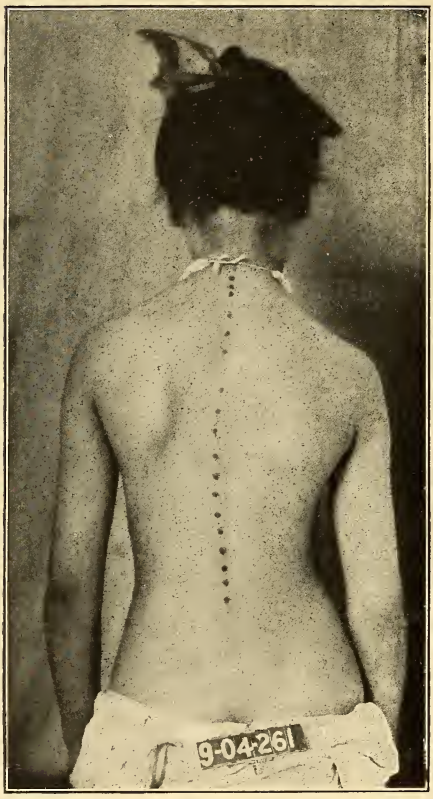


FIG. 300.—Left Total Curve Showing Elevated Left Shoulder.

Limping.—In severe cases of curves involving the lumbar region the distortion of the vertebral column is so great that the pelvis is secondarily tilted, and by this one leg is rendered shorter than the other for practical purposes and a more or less marked limp may be caused.

Structural and Postural Curves.—Curves will be found to vary not only in their localization and their amount of rotation, but also in their rigidity. This variation is due to the variation in the amount of structural change. For clinical purposes it is convenient to apply the term *structural* curves to those with evident changes in the tissues, and *postural* to those curves without definite structural changes. The latter are flexible and easily corrected by the patient's effort, by lying down or by suspension. In the latter, rotation is not a prominent symptom. These curves have also been designated as *fixed* or *habitual*. The terms *primary* and *secondary* curves are also used to define the relative clinical importance or severity of the two curves present. This application of the term is preferable to the use of these terms to designate the one first formed, as it is impossible to determine this in many cases.

Rotation.—As is explained under the head of pathology, it is impossible for any curvature to take place in the spinal column without being accompanied by rotation.

The prominence of rotation in lateral curvature is a measure of the severity of the case.

The amount of rotation may be much greater in some cases than would be expected by the slight amount of apparent lateral deviation of

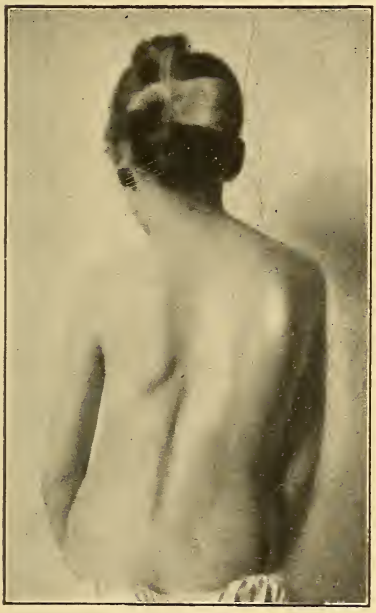


FIG. 301.—Right Dorsal Curvature Following Empyema of the Left Side.

FIG. 302.—Right Dorsal Curve, Showing Elevation of Right Shoulder, Prominent Left Hip, and Rotation of Right Chest Backward.

the spinous processes, as if the vertebræ yielded more by twisting under superincumbent weight than by curving to the side.

Rotation, as has been shown, is always toward the convex side of the lateral curve; but in childhood the so-called total scoliosis often shows a general backward prominence of one side. The backward projecting shoulder will often be found on the concave rather than the convex side. This occurs only in a flexible spinal curve, where the compensatory curve is not easily recognized or entirely established. It is perhaps the initial stage of the ordinary type of scoliosis, the long curve being afterward divided into two sections.

Relative Frequency of Curves.—The lateral curvature most com-

monly seen by the surgeon is the right convex dorsal curve. To this is frequently added a lower curve with the convexity to the left. If the trunk is displaced to the right, as is often the case in long dorsal curves, the left hip is uncovered and appears more prominent than the right, the reverse being the case when the trunk is displaced to the left. When school children are examined irrespective of symptoms complained of, many postural curves not brought to the surgeon for examination

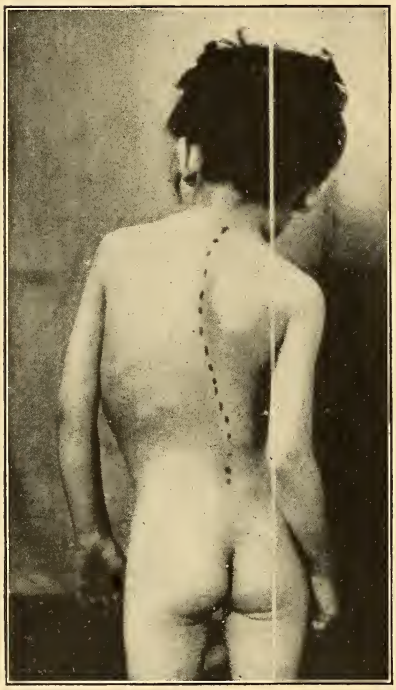


FIG. 303.—Lateral Curvature Due to Empyema of Right Chest. Five months after operation.

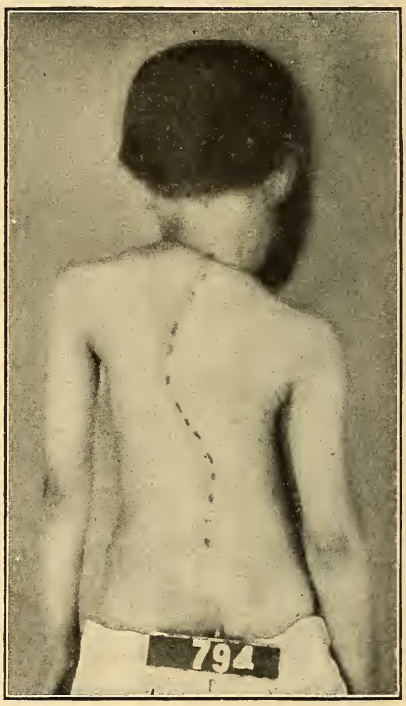


FIG. 304.—Congenital Lateral Curvature Associated with Absence of Ribs.

are seen. Of these, total curves will be found the most common, and of these, the one with the convexity to the left is the most frequent.[1]

VARIETIES OF LATERAL CURVATURE.

Rhachitic Lateral Curvature.—This form occurs in rhachitic children, but it is not so common a curve as the simple posterior curve which appears as a backward prominence in the lumbar region in so many cases of rickets. In some varieties of lateral curvature there may also be an exaggerated antero-posterior curve due to yielding of

[1] Lüning and Schulthess: "Orth. Chir.," Munich, 1901, p. 246.—Zeitsch. f. orthopädische Chir., 1902, Bd. x.

the bones under the unusual distribution of superincumbent weight. It is probable that if cases with rickets were more carefully examined, scoliosis would be more frequently observed. Truslow[1] found it in 15 per cent of 201 cases of lateral curvature, and Mayer[2] found scoliosis in 217 out of 220 rhachitic children.

Difference in Length of Legs.—A slight difference in the length of the lower limbs is the rule. But development of lateral curvature directly from this cause is not invariable, as is evident from the fact that in cases of scoliosis a notable difference in the length of the lower limbs is detected, in about the same proportion of cases as in normal children. In children with marked inequality in the length of the legs and with diminished resistance in the vertebral column, scoliosis will follow.

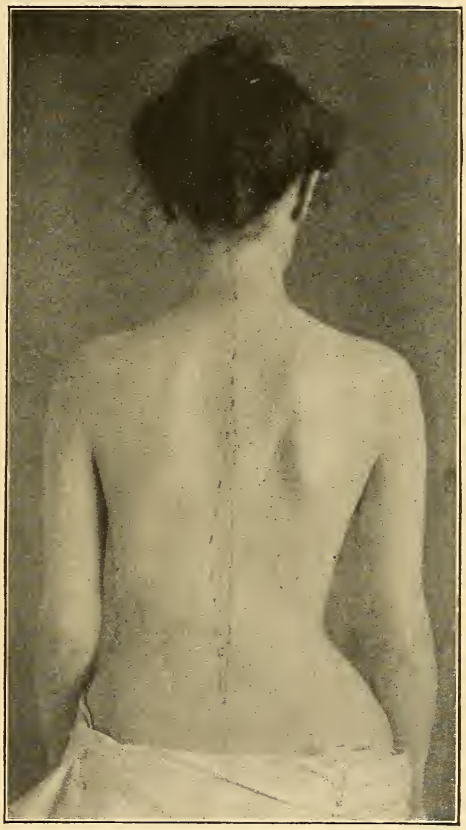


FIG. 305.—Left Lumbar Dorsal Curve.

Paralytic Lateral Curvature.—In a certain number of cases of paralysis of the muscles of the back lateral curvature of the spine is found.

When the muscles of the back are weak, the patient instinctively assumes an attitude in which the spine is balanced with the least action on the part of the weakened muscles. The curvature may be toward the side of the paralyzed muscles or away from them.[3] The bones of the spine may be distorted (if lacking in a power of resistance) by a constant vicious attitude, and a fixed lateral curvature result.

This form of lateral curvature is most commonly developed after infantile paralysis, as this is the most common form of paralysis occurring in the growing years; but the effect of other palsies, if influential

[1] Whitman: "Orthopedic Surgery."
[2] Bulletin Médical, June 15th, 1901.
[3] Arnd: Arch. f. Orthopädie, vol. i., No. 1.

in weakening certain muscles of the back, would be the same, and the distortion may be seen after spastic paralysis, progressive muscular hypertrophy, syringomyelia, and other affections weakening the muscles of the spinal column.

Torticollis.—Affections causing unequal muscular contraction of the muscles of the back will throw the spine out of balance. In this category torticollis is to be mentioned, as lateral curvature always follows this affection unless it is corrected. Inequality of vision and hearing

FIG. 306.—Severe Curvature due to Rickets.

and congenital conditions causing the head to be held to one side (T. Dwight) are possible causes of scoliosis.

Lateral Curvature from Contracture of the Chest.—Lateral curvature may follow empyema, and some deviation of the spinal column is likely to follow severe forms of empyema. In the purest forms of this type the spine is pulled to one side, the ribs being flattened, *i.e.*, fixed obliquely at a lower angle than normal, from the cicatricial contraction of the lung which prevents expansion of the lung on that side and leads to an increased expansion on the other. In certain cases the altered position so induced has its effect upon the growth of the spine.

It has been said that a curvature followed in some instances pneumonia, phthisis, and organic heart disease.

Lateral curvature may follow sarcoma of the ribs and lung.[1]

Lateral Curvature from Occupation.—Any occupation which necessitates faulty attitudes for long periods daily, favors the development of spinal curve, but lateral curvatures of severe type due to ordinary occupation are not, as a rule, common, for the reason that laborious occupations are not, in general, entered upon until an age when the spinal column has a sufficient amount of resistance to withstand the superimposed weight without developing great structural change.

Slight lateral curves may be seen, analogous to the kyphosis of those employed in occupations requiring stooping. In clerks one

FIG. 307.—Severe Case of Spastic Paralysis in a Patient who had never Walked and who from Childhood had Sat to One Side. The patient is now an adult.

shoulder is often higher than the other from the attitude of writing, and it is said to be true also in blacksmiths. Severe forms of this class are sometimes seen in adolescents whose occupation habitually twists the spine, as in carrying baskets or trays.[2]

Scoliosis in nursing women, from carrying infants too frequently upon one side, is also recorded, and the same attitude in one-armed persons.

Scoliosis seen in school children is in reality generally an occupation deformity, resulting as it does from the constant assumption of faulty attitudes, which produce abnormal pressure and strain upon growing spinal columns lacking in structural resistance.

Congenital defects in the spinal column with misshapen vertebræ

[1] Boston Med. and Surgical Journal, January 10th, 1889.

[2] Zuppinger: Zeitsch. f. orthopädische Chir., xi., p. 280.

is a cause of congenital deformity, but it is impossible in the absence of reliable statistics to determine how commonly this occurs.

Alteration in the shape of the vertebræ from disease (Pott's disease, osteomyelitis of the spine, and spondylitis deformans) may cause lateral curvature. It may also occur in Pott's disease and sacro-iliac disease as the result of muscular spasm.

Ischias scoliotica, referred to also as scoliosis neuromuscularis, or neuropathica or ischiatica, is a term which has been applied to lateral curvature in the lower part of the spinal column occurring in connection with sciatica. It is severest in cases in which the lumbar nerves are involved. The curvature may be to the side of the affected nerve, or the reverse, or it may alternate. The condition is most easily relieved by fixative appliances.

FIG. 308.—Lateral Curvature due to Infantile Paralysis of Muscles of Trunk.

DIAGNOSIS.

A diagnosis of lateral curvature, in a severe case, is so simple that an inspection of the patient is all that is required.

In the less-marked cases, however, the recognition of the true nature of the deformity is not so easy, and a careful examination is necessary, not only for the exclusion of other affections of the spine, but also for an estimate of the progress of the lateral curvature and the amount of rotation and bony change in the spinal column.

The method of examination of a case of lateral curvature is as follows:

The patient's back should be bared in ordinary cases to the level of the trochanters, and the arms should be allowed to hang free. The most natural attitude in standing should be noted and also the position of the patient in an attempt to stand in as straight a position as is possible; the tips of the spinous processes are to be marked with a skin pencil, and also the ends of the scapulæ. To determine the central line a string, to which a slight weight is attached, is hung from the seventh cervical vertebra (to which it can be fixed by a piece of adhesive plaster), the string being long enough to hang below the cleft of the buttock; or the string should be used as a plumbline to show a perpendicular, erected from the middle of the pelvis. In this case it hangs in

the cleft of the buttock, and the deviation of the spine from this vertical line can be noted. The distance of the tips of the scapulæ (the arms being crossed in front of the chest) from this central line should be measured, and also the distances from this line to the points of greatest curvature of the line of the spinous process. These points being noted, the slope of the shoulders, the outlines of the sides of the trunk, and the contour of the back, as well as any lack of symmetry or unilateral fulness, should be carefully recorded, both when the patient is standing and in the stooping position, with the back well arched. If a side deviation of the line of the spinous processes is observed, a lack of symmetry of outline, or a unilateral projection of the ribs or scapulæ, in the erect position, it should be recorded and the patient should be suspended by means of a head sling and also made to lie in a recumbent position upon the face. A marked alteration of the curvature, contour, or outlines following removal of the superincumbent weight is of particular importance.

If the curve disappears under these conditions, it is to be classed as postural. If it does not disappear, it is to be considered structural.

The patient should then bend forward with the knees straight and the arms hanging until the trunk is horizontal. In the normal spine the two sides of the back will be on a level when viewed in this position. Rotation of the ribs or lumbar vertebræ due to structural changes is shown by a greater upward prominence of the side of the back which has rotated backward. This may be measured, if desired, by a plumbline hanging from the angle between the arms of a pair of calipers. This plumbline records the variation from the horizontal in a protractor fastened at the angle of the calipers, or the apparatus (*Nivelliertrapez*) of Schulthess[1] may be used for the same purpose.

The flexibility of the spine should be tested by causing the patient to stand first with one foot and then the other upon a series of blocks half an inch in thickness, and testing what height can be placed under the patient's foot without preventing her from standing upon both legs with the limbs straight, without flexion at the knee; this tests the lateral flexibility in the lower part of the spinal column. In testing the flexibility higher up, the patient should be seated on a stool, and one hand of an assistant be placed upon her side, above the crest of the ilium, while the other hand should be placed upon the crest of the ilium of the opposite side. The patient should then be directed to bend sideways toward the side of the higher hand, and the amount of this motion, without tilting of the pelvis, is to be noted.

The lateral flexibility can also be readily seen by directing the patient to bend to the side with the hands behind the head and the feet apart, keeping the legs straight and avoiding twisting the pelvis.

[1] Lüning and Schulthess: "Orth Chir.," München. 1901. p 153.

It is not always necessary to examine the front of the patient's trunk in the case of older patients. When this is done, the projection of the ribs in front, and the difference in the prominence or flatness of the two breasts, the deviation of the tip of the sternum and of the umbilicus from the median line are of importance, as indicating the amount of structural change which has taken place. The asymmetry of outline is always to be more clearly seen from the front than from the back of the patient.

The strength of the muscles of the patient's back may be tested, if desired, by means of a dynamometer, or spring balance, and the height and weight should be recorded and compared with the normal standard for the age as given.

A diagnosis of lateral curvature in the early stage is to be made by

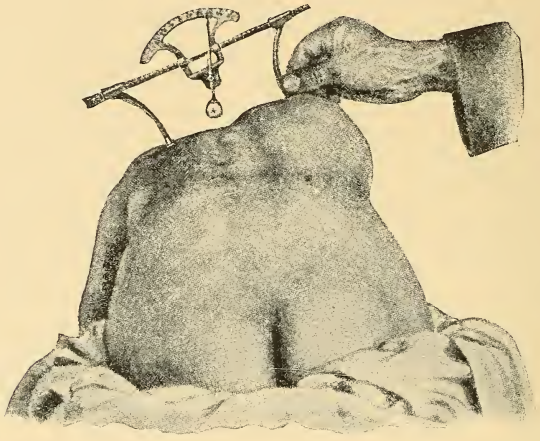


FIG. 309.—Measurement of the Rotation of the Ribs in the Horizontal Position by the Levelling Trapezium of Schulthess. (Schulthess.)

observing in any case an habitual lack of symmetry in the outline of the sides of the trunk and the slope of the shoulders, in the unnatural projection of one shoulder blade or a portion of the trunk on one side or of one hip, and on a constant deviation of the line of the spinous processes from the vertical line.

The accidental assumption of a faulty attitude does not justify a diagnosis of lateral curvature; but the habitual assumption of such a position, when the patient stands in the attitude of ease and greatest comfort, indicates an abnormal condition. The existence of slight grades of lateral curvature is made more evident by allowing the patient to stand for a minute before beginning the examination, in order to obtain the relaxed position due to beginning muscular fatigue.

The amount of structural change is indicated by the amount of stiffness and by the slight change in the curves and asymmetrical symptoms

as the patient alters the position by standing, lying, bending, twisting, and hanging. In this way it is possible to determine the amount of progress the distortion has made and the stage of the affection.

Lateral curvature is not infrequently confounded with Pott's disease through ignorance of the nature of either affection, both being classed as chronic spinal affections. In pronounced lateral curvature, the lateral twist and the rotation are essentially different from the curve of Pott's disease, which is chiefly an antero-posterior curve. In the former, rotation is an unmistakable symptom; in the latter, it is absent or slight. In the slighter cases of lateral curvature the spine is flexible and the lateral curve diminishes or disappears on recumbency; and there is never a sharp angular projection. In Pott's disease the spine is not flexible but stiff, the curve is angular, and it does not disappear on recumbency. Lateral curvature often exists in Pott's disease, but is a leaning of the whole body to one side and is associated with the signs of destructive disease.

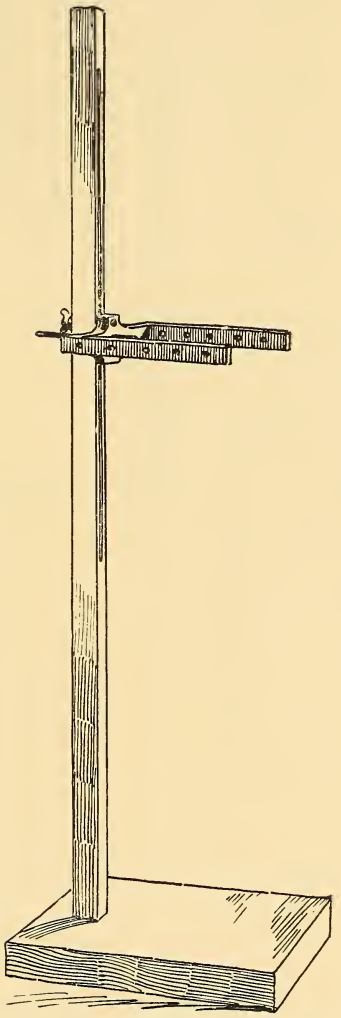


FIG. 310.—Apparatus for Recording Lateral Curvature. (Feiss.)

METHODS OF RECORDING LATERAL CURVATURE.

For clinical purposes a careful record of lateral curvature is necessary.

In recording lateral curvature it is desirable to note the flexibility of the spine, the curve, and the amount of twist or rotation, as well as the attitude and contour. Photography, if carefully employed, is of assistance.[1] For this purpose the spinous processes should be marked, and a line drawn from the seventh cervical spine to the cleft of the buttocks, which marks the median line of the body. The patient if standing should be placed squarely before a camera and photographed with an arrangement of light to prevent strong shadows. The rotation can be photographed if the standing patient stoops and the camera is

[1] Spelissy: Trans. Am. Orth. Assn., vol. xv.

focussed on the portion of the back showing the greatest rotation of the spine.

A more ready but less reliable means of record can be furnished by the following measurements made and recorded from the spinous processes to the line connecting the two ends of the spine: First, the distances between the line from the seventh cervical spine to the cleft of the buttock and the points of maximum curve of the line of the spines in the upper and lower curve if both exist are recorded; second, the distance from the spine of the seventh cervical vertebra to the point where the line connecting the ends of the spine crosses the line of curve.

A simple apparatus devised by H. O. Feiss, of Cleveland, gives a fairly accurate record of the deformity by means of series of horizontal

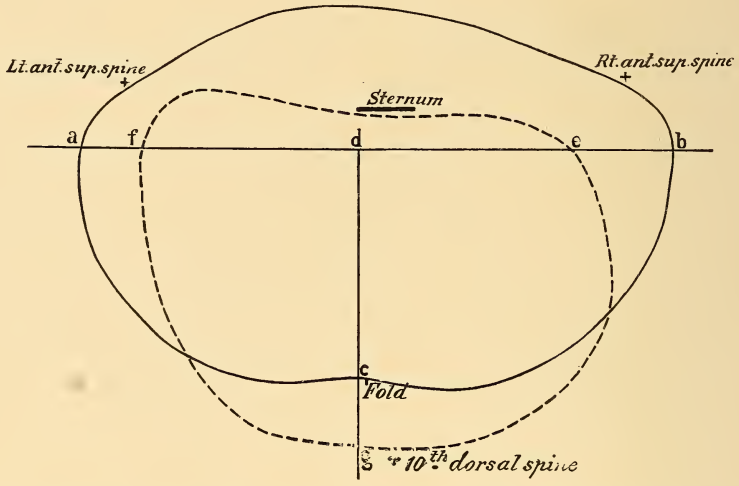


FIG. 311.—Tracings of a Case. The unbroken line representing the tracings at the level of the anterior superior spines and the broken line the tracing at the level of the tenth dorsal vertebra. (Feiss.)

tracings of the trunk at different levels, superimposed on each other in a constant relation to the median plane of the body. The patient stands on a platform, from the back of which projects a square, vertical upright, upon which slides a horizontal arm carrying at its ends two horizontal arms projecting forward. The patient stands back to the upright, and one horizontal arm is behind him and one is on each side. The anterior superior spines are marked by a pencil. By means of holes in these arms, through which a skin pencil can be inserted, three marks on the patient's skin are now made at the level of the anterior superior spines, one on the patient's back and one on each side. The upright is then pushed up to the level of the greatest deformity, and by using the same holes in the uprights three more marks are made on

the skin in the same vertical planes as the others. Points are marked in the same way at other levels if desired. Horizontal contour tracings of the back and front of the patient at the levels of the marked points are made by means of a "draughtsman's adjustable rule." The posterior lower tracing is taken first and the points on the skin are marked on the tracer, and this tracing is reproduced on paper; the anterior part of

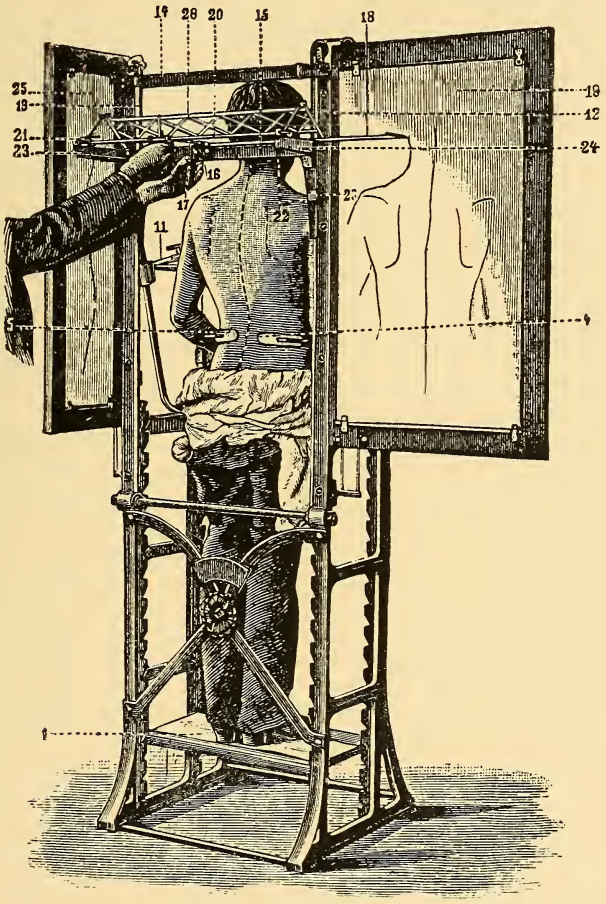


FIG. 312.—Apparatus for Recording Lateral Curvature. This machine records the antero-posterior curves, the line of the spine and outline of the body in the lateral plane and the horizontal contour of the back at any level. (Schulthess.)

the tracing is then taken and laid out on the paper. The anterior and transverse lines of the apparatus are represented by lines drawn by a T-square. The second tracing is taken in the same way and drawn upon the paper, the marked points being made to lie over the same points in the first tracing drawn. A series of tracings is thus graphi-

cally recorded, which bear the same relation to each other as the contours of the patient do at the recorded levels.[1]

Records taken in this way will serve for clinical purposes, but they lack scientific precision, as the possibilities of error on the part of the recorder are too great to be neglected. The methods answer for the use of a single observer, but not for a comparison of results in the practice of different surgeons.

The best and most accurate method of record is that to be obtained by the apparatus of Schulthess. The patient stands in a frame with the pelvis secured, and, by means of a pantagraph working from a bridge sliding up and down in the frame, an accurate record of the lateral deviation of the spinous processes, the antero-posterior curve of the spine, and the amount of rotation at different levels is obtained. The apparatus is expensive and complicated.[2]

PROGNOSIS.

Two errors in prognosis are common. First, that the disease is of the most serious nature; second, that it is a trivial affection and will be readily outgrown by the patient. The fact is, that in the larger number of these cases the affection is a self-limited one, occasioning slight deformity, which persists through life, causing no trouble and recognized only by the dressmaker or by some near relative.

In other cases, however, the disease becomes decidedly worse as the deformity increases, and a pitiable distortion follows, causing a marked deformity and perhaps neuralgic pain.

It is impossible to state positively in what instances an increase of the curve will take place and when they can be relied upon to remain stationary. It may, however, be said that when the physical condition during the growing period remains constantly below the proper standard, and when the patient's growth is rapid, an increase of curve is to be apprehended. The decrease or diminution of lateral curvature from simple growth without treatment is not to be expected.

Sometimes the disease may remain to a slight extent during girlhood and early womanhood, developing an increase at a period past middle life. Such cases are dependent upon a loss of general health and upon trophic changes occurring at this period of life.

In determining the prognosis the probable rate of growth is to be borne in mind.

This can be ascertained by the patient's height, the hereditary tendency toward height as ascertained by the height of the parents and the parents' families. The general opinion is that completion of growth exerts a powerful influence in arresting progress of the curvature.

[1] H. O. Feiss: Boston Med. and Surg. Journ., 1905.

[2] Lüning and Schulthess: "Orthop. Chir.," München, 1901, p. 147.

In general it may be said that if a patient has gained full height and development in figure, any increase in growth is not often to be expected, and that an increase in curve is not probable after the osseous system has become thoroughly formed and the strength of the spinal column established.

The normal height and weight of male and female are here given for the sake of reference.

TABLE OF HEIGHT AND WEIGHT OF THE HUMAN BODY.

Male.

Age.	Height in Feet and Inches.	Weight.
At birth	1 ft. 7 in. (0.496 m.)	7 lbs. (3.20 kgm.)
1 year	2 " 3 " (0.696 ")	22 " (10 00 ")
2 years	2 " 8 " (0.797 ")	26 " (12 00 ")
3 "	2 " 9 " (0 860 ")	29 " (13 21 ")
4 "	3 " (0.932 ")	33 " (15 07 ")
5 "	3 " 3 " (0 990 ")	36 " (16.70 ")
6 "	3 " 5 " (1 046 ")	39 " (18.04 ")
7 "	3 " 8 " (1.112 ")	44 " (20.16 ")
8 "	3 " 9 " (1.170 ")	49 " (22.26 ")
9 "	4 " (1.227 ")	53 " (24.09 ")
10 "	4 " 2 " (1 282 ")	57 " (26 12 ")
12 "	4 " 6 " (1.359 ")	68 " (31 00 ")
14 "	4 " 10 " (1 487 ")	89 " (40 50 ")
16 "	5 " 3 " (1.610 ")	117 " (53 39 ")
18 "	5 " 6 " (1.700 ")	135 " (61.26 ")
20 "	5 " 8 " (1.711 ")	143 " (65.00 ")
25 "	5 " 9 " (1.722 ")	150 " (68.29 ")
30 "	5 " 9 " (1 722 ")	152 " (68.90 ")
40 "	5 " 8 " (1.713 ")	151 " (68.63 ")

Female.

Age.	Height in Feet and Inches.	Weight.
At birth	1 ft. 6 in. (0.483 m.)	6 lbs. (2.91 kgm.)
1 year	2 " 3 " (0.690 ")	20 " (9.30 ")
2 years	2 " 6 " (0 780 ")	25 " (11 40 ")
3 "	2 " 9 " (0.850 ")	27 " (12 45 ")
4 "	3 " (0.910 ")	31 " (14 18 ")
5 "	3 " 2 " (0 974 ")	34 " (15 50 ")
6 "	3 " 4 " (1.032 ")	37 " (16.74 ")
7 "	3 " 7 " (1.096 ")	40 " (18.45 ")
8 "	3 " 9 " (1.139 ")	43 " (19 82 ")
9 "	3 " 11 " (1.200 ")	50 " (22 44 ")
10 "	4 " 1 " (1.248 ")	53 " (24.24 ")
12 "	4 " 4 " (1.327 ")	67 " (30 54 ")
14 "	4 " 9 " (1.447 ")	84 " (38 10 ")
16 "	4 " 11 " (1 500 ")	98 " (44 44 ")
18 "	5 " 1 " (1.562 ")	117 " (53 10 ")
20 "	5 " 2 " (1.570 ")	120 " (54 46 ")
25 "	5 " 2 " (1.577 ")	121 " (55.08 ")
30 "	5 " 2 " (1.579 ")	121 " (55 14 ")
40 "	5 " 1 " (1.555 ")	129 " (58.45 ")

Prognosis under Treatment.

Theoretically, lateral curvature is a deformity which can not only be prevented, but if treated in time can be cured. Practically, cases are often brought to the surgeon after structural changes have taken place and the tissues have become resistant. They are often in the condition of cases of humpback after a cure has been established with a persistent deformity, when a complete rectification of the curve is not advisable on account of the severity of the treatment. If cases of scoliosis have little structural change, improvement can always be obtained, and often this can be made a permanent cure. In cases with evident structural change in the growing years, diminution of the curve is to be expected to follow thorough treatment. In rigid cases an improvement of condition and carriage can be hoped for. The prospects of treatment are, of course, better when it can be carried on during the period of growth.

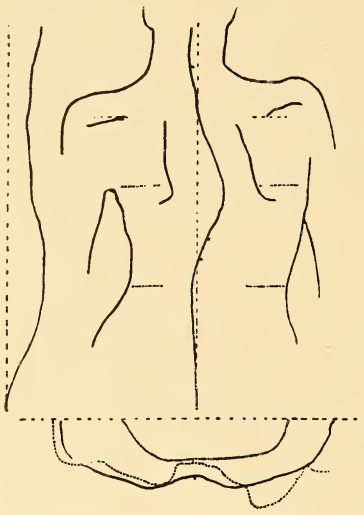


FIG. 313.—A Record Made by the Machine Shown in Fig. 312. At the left is the outline of the upright spine. Below are the contours of the back at three different levels. (Schulthess.)

PREVENTIVE MEASURES.

As faulty attitudes exert an influence in causing lateral curvatures, the avoidance of these is of importance in preventing curves.

Attitude at School.—The attitude assumed during school work deserves careful consideration, as the injurious effect of improper attitude has been proved by statistics which show the prevalence of curvature among school children, and by the increase of the deformity in school years.[1] The prevalence of faulty attitudes in school has been shown by Scudder[2] and others. In an examination of the attitudes of 1,484 school children seated in the schools of Boston and its neighborhood, sixty-seven per cent were found to be in incorrect position at the time of observation.[3]

An examination of the attitude assumed in writing by sixty-seven healthy adult males, while writing in a three-hour written examination,

[1] Scholder: "Schuleskoliosis." Archiv f. orthop. Chir., i., 2.—Freeman: Archives of Pediatrics, June, 1904

[2] Report Boston School House Dept., 1904.

[3] L. M. Towne: "Physical Education Review."

showed at the end of two hours that in all the paper was inclined slightly, so that the written line formed an angle with the cross axis of the thorax. This angle varied from ten degrees to a right angle. The inclination of the paper was always such that the right upper corner was in front of the left. In a large majority of the writers the left side of the hip was in front of the right, the left shoulder in front of the right, but the left ear was usually slightly lower than the right and somewhat behind it. In all cases, therefore, there was a slight rotation of the spinal column. The trunk in three-fourths of the writers was inclined to the left, in about one-quarter to the right, and in the remainder it was held erect. It may be fairly assumed that, if a twist of the spinal column is invariable in writing in strong men, faulty attitudes will be equally common in weakly children.

School Furniture.

In the prevention of scoliosis proper school furniture is essential.

Seats.—Chairs used by children rarely support the back muscles adequately, which may be unduly stretched and thereby weakened. Children often assume faulty attitudes simply for the reason that proper support is not furnished the lower part of the back. They are apt to sit sideways, the trunk being supported on one tuberosity of the ischium. The seat of the chair in which the child is to sit for any length of time should not be deeper than the length of the thighs or higher than the length of the legs; its back should not be above the shoulders and should be arched so as to fit in the hollow of the back.

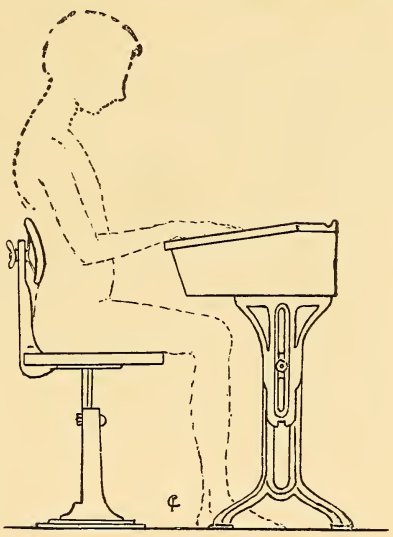


Fig. 314.—Diagram of the Adjustable School Chair Adopted by the Boston Schoolhouse Commission. (F. J. Cotton.)

If this is not done, the large muscles of the back will be unduly strained, as they are inserted into the broad fascia which is attached to the sacrum and iliac bones, and faulty attitudes will be instinctively assumed by the patient. This is shown if tracings be taken of the back of a child in the various attitudes of sitting, leaning forward, backward, and sitting unsupported.

The back of the chair should slope backward slightly, forming an angle of 100° to 110° with the seat. The back of the chair should be arched with the convexity forward, the greatest convexity correspond-

ing to the physiological curve in the hollow of the back. The back of the chair should be constructed so that it will serve as a support to the spine when the child leans backward, and especially to that portion of the back which is in most need of support and subject to the greatest strain, *i.e.*, the lumbar region. The backs of most chairs simply touch the shoulders of children in the upper dorsal region.

The following measurements are adapted from Staffel:[1]

	I. 6–9 years.	II. 9–12 years.	III. 12–15 years.	IV. Adult.
Height from seat to floor	33 cm.	37 cm.	41 cm.	47 cm.
Height from seat to middle of lumbar projection of chair	21 "	23 "	25 "	27 "
From edge of seat to vertical line drawn from lumbar projection to seat	26 "	30 "	34 "	38 "

The writing-table should be at a height proportionate to the height of the person sitting. The distance from the top of the seat to the top

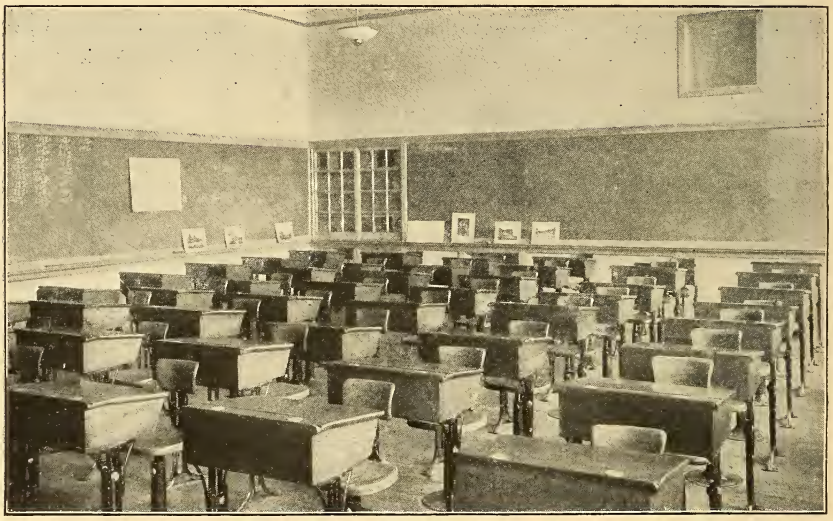


FIG. 315.—School-room Fitted with Adjustable School Chair in Use in the Newer Boston Schools. (Report of Boston Schoolhouse Commission, 1904.)

of the table should be one-eighth of the height of a girl, and one-seventh of that of a boy. The height can also be determined in the following ready way: The distance from the olecranon of the bent arm to the seat with two inches added should be the distance from the seat to the top of the desk. The edge of the table should be just over the edge of the chair. The inclination of the top of the desk should be a slope of two inches in a breadth of twelve. Adjustable school furniture is of

[1] Staffel: Centralblatt f. orthop. Chir., May 1st, 1885.

great importance in furnishing to school children suitable desks and seats.

The chair adopted by the Boston School Commission after experimentation and measurement, and adopted for use in 1903 in all new and refitted school-rooms, is one meeting most of the requirements and one which has proved practically of use.[1]

A chair furnishing support to the back and permitting a change of position without loss of support has been devised by Professor Miller of the Massachusetts Institute of Technology and Dr. Stone, of Boston.[2]

Attitude in Writing.—That the development of scoliosis may be influenced by a twisted attitude in writing would appear from the dif-

FIG. 316.—School-room Shown in Fig. 315, Showing Scholars Seated. (Report of Boston Schoolhouse Commission, 1904.)

ferent percentage of spinal curvatures found in different schools in different cities, where the oblique and vertical writing are taught:[3]

	Oblique Writing. Per cent.	Vertical Writing. Per cent.
Nuremberg	24	15
Zurich	32	12
Munich	24	15
Furth	65	31
Wurzburg	28	8

Although too much credence can easily be given to statistics with

[1] Reports of Boston School Commission, 1903 and 1904.

[2] Trans. Amer. Orthopedic Assn., vol. xii.

[3] Schulthess: "School Scoliosis," Hamburg, 1903.—Scholder: Arch. f. orthop. Chir., i., 3.

such variation of percentages, it would appear to be probable that in oblique writing especial pains will be needed to prevent a twisted attitude in writing.

The proper attitude during writing is with the transverse axis of the trunk parallel with the edge of the writing table. The forearms should rest at least two-thirds of their length upon the table. The trunk should be held erect, the legs should be straight before the trunk.

School Hygiene and School Gymnastics.—Proper lighting of schoolrooms and the correct placing of blackboards are essential in favoring proper attitudes. The avoidance of long sitting periods by introducing gymnastic exercises and changes of position is of importance.[1] It is evident that gymnastic exercises are of little benefit if not carefully and efficiently supervised.

Correct Carriage.—Faulty attitudes are frequently assumed in walking and in standing, especially by young children. The inclination to stand upon one leg is usually a habit, but in some cases it may be due to a muscular weakness of one limb or of a knee or ankle. The habit is to be corrected by drill or by muscular exercise, and by encouraging activity with the necessary constant change of position. Incorrect habits in sitting at home are to be remedied by insisting that the children with curvature shall not sit curled up or bent over in reading, but that they shall sit in suitable chairs and hold the book correctly.

Attitude during Sleep.—The most common attitude in sleep is upon the side, but decubitus upon the back is more common than on either single side. The right side is more commonly lain on than the left, but the difference is slight; young children and men not infrequently lie upon the belly, but the attitude is not assumed by women or growing girls.

The fact that a right-sided decubitus is to be avoided in a right dorsal convex curve makes these facts of value.

In ordinary cases the precautions at night which should be observed are that the patient should not be allowed to sleep with many pillows and that the bed should be a firm one. The child should not be allowed to assume a twisted position, but should lie upon the back or the side of the greatest concavity. In threatening cases measures are necessary to preserve a proper position. This can be done by means of bed frames, described under Pott's disease.

Proper Clothing.—Much has been said about the injurious effects of corsets, and there is no doubt that the muscles of the trunk are weakened by the wearing of them.[2] The injury from compression may be made less by elastic lacings and by the use of waists instead of corsets.

[1] Report National Committee on Education, Washington, 1894-95, p. 449.—*Ibid.*, 1895-96, p. 1174.

[2] Hutchinson: New York Medical Record, April 27th, 1889, p. 464.

That growing girls should be furnished with clothing which does not constrict the trunk needs no argument. The use of side garters, which fasten tightly drawn long stockings to waists dragging upon shoulder straps and shoulders, is to be avoided. This can be done by the use of round garters or attaching the garters to properly constructed shoulder straps independent of the waist and designed to draw the shoulders backward and not forward. Heavy petticoats should not be attached to waists with shoulder straps dragging upon the shoulders of growing girls. This can be avoided by the use of union suits for underwear and light petticoats.

TREATMENT.

Several difficulties are to be met in treating lateral curvature. As the affection is active during the period of growth, treatment, to be efficient, must be carried on for a long time, and is tedious to the surgeon and irksome to the patient. Furthermore, as the disease is one that does not threaten life and is slow and uncertain in its outcome, it is sometimes difficult to enforce the proper treatment for the requisite length of time. Again, danger of increasing deformity varies at different periods of the trouble, and consequently methods which are necessary at certain stages of the affection are not needed at others. Cases will be brought to the surgeon's care presenting varying degrees of deformity and needing different grades of treatment. Cases, however, can be grouped in two classes:

I. Those with slight structural change and curves in the main flexible. The treatment of this class is directed to improving the patient's attitude, in the expectation that if faulty attitudes are rarely or never assumed there will be no danger of an increase in the structural changes of the curve. The treatment is either *postural*, directed to the forming of correct habitual attitudes; or *gymnastic*, directed to strengthening weak muscles and thereby favoring correct carriage.

II. Those with structural change and curves which are fixed. In these cases corrective treatment is directed primarily toward correcting existing curves.

I. Treatment of Flexible Cases.

Postural Treatment.—The postural treatment consists in the correction of faulty habits, the development of weak muscles, and the retention of proper attitudes. As a raw recruit is taught the position and carriage of the soldier, so children, if faulty habits of attitude are present, are to be drilled into standing and walking in correct attitudes. This method is suited for the simplest cases of beginning curvature. To be thoroughly carried out, it requires that the patient should daily be exercised in walking, standing, and sitting properly for a specified time under the direction of some competent person. The principles of

the "setting-up" drill of recruits in all armies are applicable, with modifications, to patients of this class. When resting during the hour of drill the patient should remain recumbent. After the drill is over, such precaution should be taken as will prevent the persistence for any length of time of a faulty attitude. This should not be done (out of the drill time) by constant correction, but by the proper arrangement of the play hours and a supervision of the chairs when reading and studying. Walking, running, and active games should be encouraged, while reading, except in proper position, should be discouraged. The treatment is strictly postural.

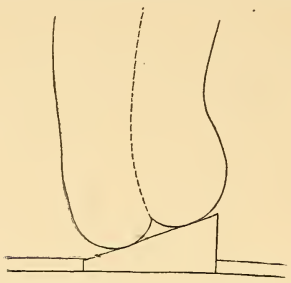


FIG. 317.—Seat Elevated on One Side for Changing Lumbar Curves.

The usual bad habits of position are as follows: standing on one leg, sitting at too low a table, sitting in a twisted position, and sleeping always on one side with too high a pillow for the head.

Gymnastics.—In many early cases the faulty attitudes are clearly the result of muscular weakness. The increase in height has not been accompanied by a corresponding development in muscle. This condition is frequently met in rapidly growing children, and is one of the most common causes of lateral curvature. Here proper gymnastics are indicated, but they should be prescribed and carried out with much care. In the more marked cases the children are unable to bear much exercise without fatigue. Those exercises, therefore, chiefly needed in correcting the deformity should be the only ones prescribed. The usual class-work of gymnasium is to be avoided, as such cases require the individual attention of a competent person, who will see that no faulty position is taken during the exercises.

Each case may be regarded as far as exercises are concerned as a separate problem to be worked out individually.

LIGHT GYMNASTICS.—It is not a difficult matter to devise simple and practicable exercises to develop the muscles chiefly at fault, viz., the muscles of the back and loins. The strength of a patient's back muscles can be determined in a ready way by attaching a cord to the front of a cap tied to the head, and fastening this cord to a spring balance. The patient, seated and strapped to a seat at the proper distance from the spring balance, held firmly by an assistant, is directed to bend backward, keeping the back straight so far as is possible. This exercise is repeated as many times as advisable.

The patient stands with the heels, back, and occiput against a projecting corner (of furniture or doorway), and places the elbows (the arms being flexed) as far back as possible.

The patient, seated on a stool or chair, should place the feet behind, and on the inner side of, the front legs of the chair, and slowly bend sideways; the assistant, resisting on the head, determines the strain on the muscles of either side.

General developmental exercises for the back, shoulders, and abdomen, when taken with the spine straight and the carriage of the body correct, constitute the best general scheme for the treatment of such cases.

Cases will be seen of such feeble muscular strength that it is advisable to begin with those which demand the least muscular effort in

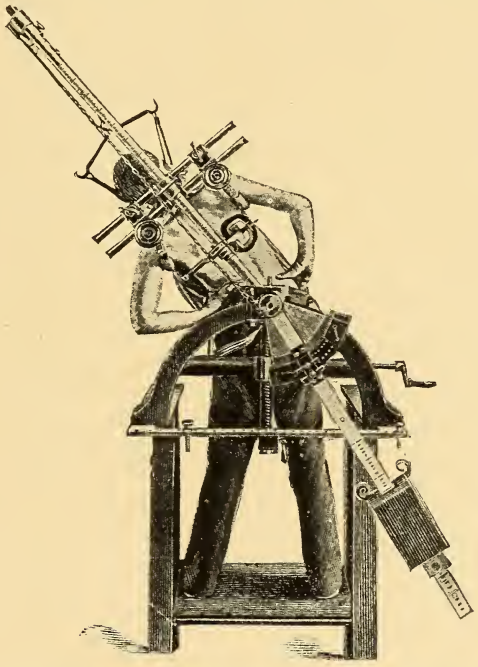


FIG. 318.—Trunk Bending Apparatus, Raising the Weight and Localizing the Movement. (Schulthess.)

maintaining a symmetrical attitude. For these cases exercises with the patient recumbent are desirable, such as the following:

1. The patient lies upon the back with arms at the side, the feet are held, and the patient raises the head and chest.

2. The patient lies on the face and raises the head and chest.

3. The patient takes 1 and 2 with the arms behind the head and the elbows squared back.

4. The patient lies on the face with the trunk projecting over the edge of a table and the hands on the hip, and raises the trunk to a horizontal position.

The same exercises, if repeated with the arms extended above the head, require more muscular effort.

If the patient has gained sufficient strength, a series of light dumbbell exercises with bells weighing from one to five pounds can be prescribed, carried on with the patient recumbent, similar to those just mentioned. Care should be taken that they are correctly performed.

After this, follow light symmetrical dumbbell exercises with the patient standing in a correct position. The work of the patient should be tabulated and carefully graded. This is to be followed by heavier work of the same general type.

Heavy Gymnastics.—The method of muscular development by means of the use of heavy weights has been employed with advantage in cases of scoliosis. This was first thoroughly carried out by Teschner, of New York,[1] and in many cases has been followed by excellent results.

The patient should exercise daily with light dumbbells weighing from one-half to five pounds, and three times a week exercises under supervision with heavier weights should be taken. The weight of these heavy bars and bells and the amount of the exercise depend upon the strength, capacity, and endurance of the individual. Each patient is put to his limit of work at each visit, and this limit is extended at each visit. This increase is largely dependent on correctness of posture and precision in the work.

Bells weighing from five pounds to twenty and thirty pounds each and steel bars and bar-bells weighing twenty-six pounds and upward can be used. The exercises are as follows:

Bells are pushed from the shoulders above the head alternately as often as the patient's strength permits. The patient swings a heavy bell with one hand from the floor, above the head and down again, the elbow and wrist being fixed and the motion repeated as often as possible in a systematic manner; then with the other hand the same number of times, and later with both hands. This exerts all the extensor muscles from the toes to the head in rapid succession.

When a heavy ball is pushed or swung above the head on the side opposite the scoliosis, the action of the back muscles is such as to cause the curved spine to approximate a straight line. A similar result is produced when a heavy weight is held by the side of the erect body on the scoliotic side, the arm being at full length.

When a heavy bar is raised above the head with both hands, the patient must fix the eyes upon the middle of the bar to maintain the equilibrium. This necessitates the bending of the head backward, the straightening and hyperextending of the spine, and consequently cor-

[1] Annals of Surgery, August, 1895; Orth. Trans., vol. ix.—Erich: N. Y. Med Journal, October 7th, 1899.

recting a faulty position with a weight superimposed. The heavier the weight put above the head, whether with one hand or with two, the more the patient must exert himself to attain and maintain a correct or an improved attitude in order to sustain the equilibrium.

When a patient lying supine upon the floor raises a heavy bar above the head so that the arms are perpendicular to the floor, the weight of the bar, the position and weight of the body, and the action of the muscles tend to broaden the entire back and shoulders, and a

FIG. 319.—Paper Jacket, Hinged. (Weigel.)

slow downward movement tends to widen the entire chest, and most markedly the shoulders. Pushing the bells above the head, swinging them with each hand and with both hands together, raising a bar above the head standing and lying down, and the exercises above enumerated constitute a day's work.

Whether light or heavy exercises are used, persistence is necessary for success. It is needless to add that the patient should exercise under careful supervision, rest being prescribed as a part of the daily treatment, the amount of work being regulated each day.

Asymmetrical Gymnastic Exercises.—Exercises formulated with the expectation of isolating certain weak muscles in the back will, as a rule, be found impracticable, for the reason that it is difficult to determine the weakness of any individual muscle, and because in a lateral curve it is difficult if not impossible to exercise a weak muscle on the convexity of a curve without the danger of exercising also the strong muscle of the compensatory curve. As a rule, symmetrical muscular exercises with the body held as symmetrically as possible are the most practicable in lateral curvature. A few asymmetrical ones may be used if marked difference in the strength of one arm or leg is present, and an increased amount of work can be given to the weaker limb or side.

Fixation Appliances.—It is manifest that during the formative period of growth faulty attitudes are to be avoided. Recumbency being inapplicable for a long period, and gymnastics being possible only for a limited portion of the day, some form of appliance which checks faulty positions is often desirable.

Corsets made of plaster-of-Paris, leather, paper, and celluloid, or cloth stiffened with steel, act as supports and limit faulty positions. Weakening of the muscles from the use of such appliances must be combated by systematic gymnastics. These appliances should be removable if designed simply as means of preventing faulty attitudes, and are made in the same way as removable corsets for the convalescent stage of Pott's disease, except that they are modelled to correct certain positions and not to fix the spinal column. In general, support of this sort is indicated when the patient shows no marked improvement under gymnastic work, but drops back after each exercise period. It is evident that under these conditions no satisfactory progress will be made without support.

When side inclination of the trunk exists to such an extent as to make the lumbar curve the chief curvature, raising the pelvis (by placing an increased thickness under the sole of the shoe on the apparently lower hip, and a pad under the lower buttock in sitting) will serve as partial correction.

II. Treatment of Structural Cases.

Corrective Measures.—When shortened ligaments and muscles are situated so that they serve as a check to the free movement of the spine, purely muscular exercises are not sufficient for corrective stretching. Gymnastics alone are therefore inadequate as a system of treatment in cases of this class, although useful as an adjuvant and as a prevention of relapse after correction by other means. It has been proved by clinical experience and by experiments on cadavers that pressure upon certain parts of the thorax—that is, on the ribs—is effective in correcting the distortion of the spinal column in such structural cases.

This corrective force needs to be adequately and correctly applied, and is analogous in its aim to the repeated correction used by those training themselves to become contortionists or dancers.

It is also true that bending the trunk to the side by force moderately applied will often place the spine in an improved and corrected position. Such procedures as these increase the flexibility of the spinal column in the desired direction and make improved attitude possible. It is manifest, however, that if a corrective force is to be beneficial in scoliosis it must be made effective on the curved and not on the normal portion of the spine. The spinal column above and below the curved part where the corrective force is to be applied must be secured; otherwise the more flexible and normal part of the spine will be more affected by the corrective force than will the abnormally rigid, curved, and twisted part. This is true not only of corrective force applied by pressure, but of attempts to correct the curve by posture and exercises which have as their aim the stretching of shortened ligaments.

Pressure to the ribs for this purpose should be applied as near their attachment as possible, in order to spend as much of the force as possible in correcting the deviation of the spine and as little as possible in bending the ribs on the spine.

Corrective measures are either applied *intermittently* in the milder cases or *continuously* in the more resistant cases.

Intermittent Correction by Exercises.—These can be given with much precision by means of elaborate appliances devised for the purpose, of which those used by Schulthess are the best. Simpler forms can be employed with benefit if care is exercised in localizing carefully the correcting force. These involve some mechanical restraint of a portion of the patient's trunk and swinging or stretching the rest of the trunk in a direction to straighten the curve. Great care is necessary in these exercises, which are flexibility exercises and not primarily designed to strengthen the muscles. There is a danger of increasing the flexibility of the wrong portion of the column and increasing the compensatory curves. A few exercises of this type may be mentioned. Any loss or impairment of spine flexibility, local or general, should be remedied, as a normal flexibility in all directions is an important matter. Symmetrical stretching is of use in such cases. As examples of this may be mentioned:

1. Hanging by the arms or suspension by the head in a Sayre sling.

2. The patient stands with the head and shoulders in a Sayre sling; the feet are fastened to the floor, and the patient rotates the trunk through a circle, first in one direction and then in the other.

3. Sitting or standing, the patient rotates the trunk from right to left, and then from left to right.

4. The patient hangs from a bar and by a muscular effort rotates the

pelvis and legs, first in one direction and then in the other. This exercise should be done with some force.

If round shoulders, contracted chest, or pronated feet coexist with the lateral curve, suitable exercises should be added.

As examples of *asymmetrical exercises to increase flexibility*, the following may be mentioned:

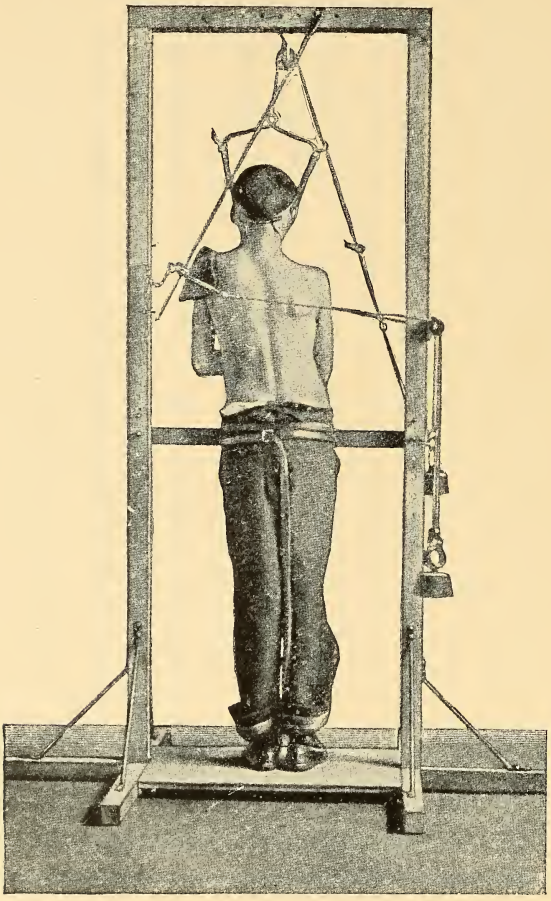


FIG. 320.—Apparatus to Afford Resistance to the Left Shoulder, which Pushes to the Left Against the Pad Raising the Weight on the Right Side of the Apparatus. The pelvis is fixed. (Schulthess.)

1. The patient sits or stands with the legs apart and bends to the side of the convexity of the curve, or, with the arm of the concave side across the top of the head and the arm of the convex side around in front of the abdomen, the patient bends to the convex side through the ribs and not through the waist.

2. The patient lies on the face with the feet held. With the hands behind the head and the elbows raised, the body is raised and swayed toward the convex side, the patient trying to "pucker in" the bulging ribs and *not* to bend in the lumbar concavity.

3. The patient stands with the convex side leaning against the padded edge of a table or a padded roll, and bends over the pad which presses against the convexity.

4. The patient stands with the feet apart and, in a right dorsal, left lumbar curve, the right hand is placed against the convexity on the ribs with the elbow out from the side, and the left arm on top of the head or on the left side of the pelvis, according to the position which

seems to give the best correction. The right hand then presses the convexity to the left, using as much force as possible.

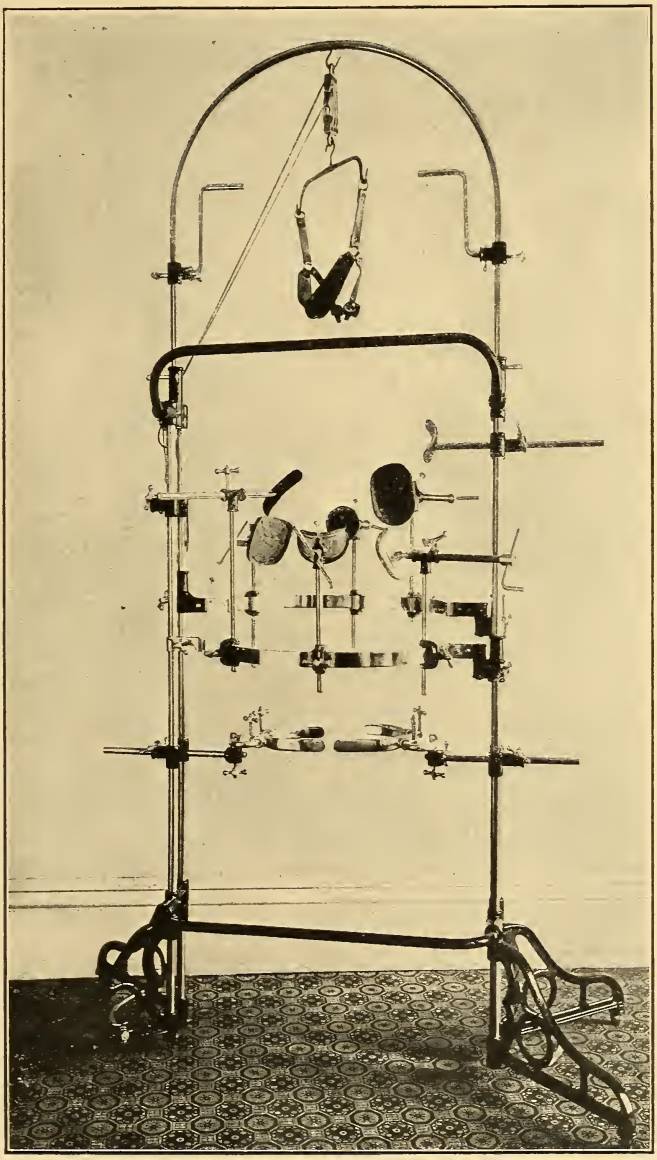


FIG. 321.—Apparatus for the Forcible Correction of Lateral Curvature in Suspension. (Weigel.)

5. Remembering that a twist to the right causes a left lateral curve, beginning below above the lumbar region, a twist to the right may be

used as an exercise for antagonizing a curve to the right in that region. The patient sits back to the surgeon, the hands behind the head and the elbows squared back, and, while the pelvis is held, twists the head and shoulders as far to the right as possible.

The variations to be made in these exercises are many, but complicated exercises are undesirable, as it is not possible to analyze their anatomical effect, and the risk necessarily involved in asymmetrical work of inducing or increasing compensatory curves is increased.

Such exercises should be given with great care, with the back exposed to view as a rule, and should be followed by a period of rest. In order to make such exercises effective in the spine the pelvis should in all cases be fixed during the exercises.

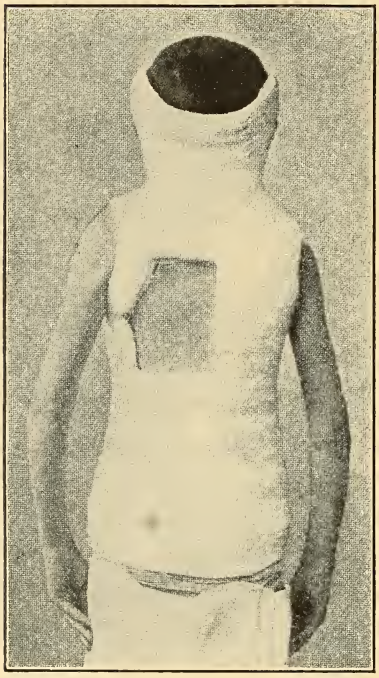


FIG. 322.—Corrective Plaster Jacket with Head-piece Applied for the Correction of Scoliosis. (Wullstein.)

The rules for the simultaneous use of supporting appliances are the same as those given in speaking of flexible curves.

INTERMITTENT STRETCHING BY APPLIANCES.—Intermittent corrective force may be applied passively for stretching at frequent periods by means of appliances to be mentioned in speaking of the use of corrective jackets. This procedure is advisable when free standing or other exercises need to be reinforced temporarily by more accurately localized stretching. The same procedure is advisable in many cases as a preliminary to the application of corrective jackets, in order to obtain beforehand greater flexibility in the direction of correction.

Corrective Measures—Continuous Use of Force.—In certain cases the curves are too resistant to be altered materially by intermittent correction. In suitable cases attempts can be made to correct the curves by a method of constant pressure, as it has been demonstrated that the shape of bone is altered by constant pressure. This is shown not only in dentistry in the success in altering the shape of the jaw, in the correction of congenital club-foot with congenital bone changes, but also pathologically in the artificial development of structural changes in bone seen in the Chinese lady's foot,[1] Wullstein's experiments in the

[1] P. Brown: Journal Med. Research, December, 1903.

artificial development of lateral curvature already mentioned, in the production of lateral curvature in different occupations,[1] and in the alteration of the jaw from scar contraction after burns and the alteration of the shape of the face in torticollis. For the application of this method, *plaster jackets* should be applied to the patient in a corrected or over-corrected position.

It is evident that this method of correction is chiefly applicable during the growing period.

Corrective plaster jackets can be applied, as for caries of the spine, with the patient in a standing or sitting position or recumbent, either lying on the face or back. Jackets are applied as for caries of the spine, but much more skill is required, as the amount of correcting force and method of applying require the exercise of judgment. If a good

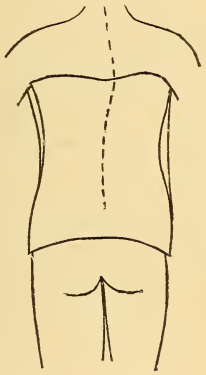


FIG. 323.—Diagram of Plaster Jacket.

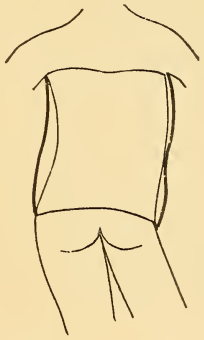


FIG. 324.—Slipping of Plaster Jacket.

deal of force is employed, the patient may be exposed to subsequent discomfort. It is usually preferable to use correcting force without an anæsthetic and apply jackets at short intervals.

Suspension or a traction force is manifestly of less value than in caries of the spine, as the affected portion of the spine in lateral curvature is always the most resistant portion, while in caries the curve, if in a stage suitable for treatment, is less resistant. The most economical application of force in straightening a stiffly curved stick is by bending it over a resistant pressure rather than by pulling each end. Experiments on cadavers show that this is applicable to the human trunk.[2]

If the patient is seated or standing, a head sling will be of assistance, with some suspension force to steady the upper part of the trunk. Traction force may be used in the recumbent position, though it is rarely needed.

[1] Lane: Guy's Hospital Reports, xxviii.

[2] Lovett: American Journal of Anatomy, 1904.

The relative advantages of the different positions of the patient in the application of a corrective jacket are as follows:

With the patient standing or seated it is much easier to apply the bandage on all sides of the patient than when the patient is recumbent, and for this reason is preferable in applying jackets to the neck and shoulders. In the upright position the position of the head relative to the thorax is that usual in locomotion, while in recumbency an alteration in the normal thorax takes place. Recumbently applied jackets are therefore less comfortable to the patients than those applied with the patient upright.

If the patient is seated it is easier to correct lordosis or any torsion of the pelvis than if the patient is standing, but in the seated position

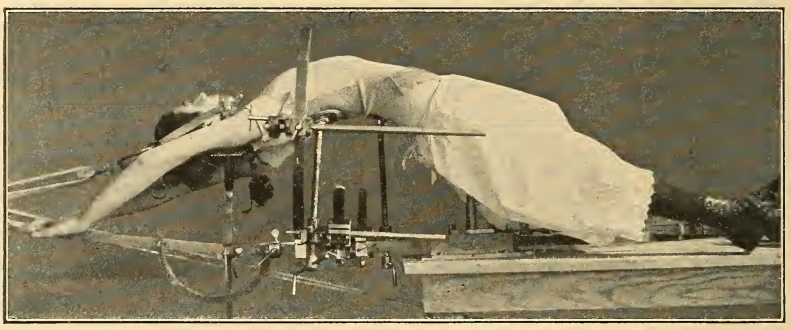


FIG. 325.—Apparatus (Kyphotone) for the Application of Forcible Jackets in Scoliosis during Recumbency on the Back. (R. T. Taylor.)

the surgeon needs to take especial pains in arranging the seat so as to enable him to apply a jacket which will hold the pelvis firmly.

Much greater correcting pressure can be applied with the patient in a recumbent position, as the superimposed weight is not an influence to be opposed. In recumbency on the face lordosis can be overcome more readily than if the patient lies upon the back. It is less easy, however, to secure a desirable expansion of the chest and arching backward of the spine in the dorsal region in face than in back recumbency. Where there is much rotation to be corrected, the recumbent position is to be preferred. Where side deviation is the more important feature, the upright position is to be considered also.

The simplest method of application of a corrective jacket is for the patient to sit or stand in the centre of a four-upright frame. The head is secured in a head sling with moderate traction. Webbing straps pass from the different uprights and can be made to exert pressure in different directions as desired. These are included in the jacket, the emerging portions being cut off. A more complicated appliance, with more precision in the application of the force, is one furnished

with circular steel bands connected with the uprights. From these adjustable bands screw pressure rods can be made to exert pressure on all desired parts of the trunk.

In the recumbent position the patient may be placed with the back supported on a frame with uprights similar to that used in the application of corrective jackets in Pott's disease, except that the pressure points are applied in the back, not upon the transverse processes, but upon the backward prominence of the ribs. Correction of lateral deviation can be furnished by horizontal traction, if necessary, or by side pressure. Felt padding is needed over the portions of the body which

FIG. 326.—Apparatus for the Application of Plaster Jackets during Recumbency on the Face.

are but little protected by fatty tissue; the plaster bandages should be applied high up under the drooping shoulder and over the shoulder from behind, across the neck. When the plaster is sufficiently hardened the patient can be lifted, the detachable plates which are thoroughly padded remaining in the jacket.

A simple method of application of a corrective jacket in an inclined or recumbent position is to secure the patient firmly in the centre of the four-upright frame used for applying a jacket in the upright position and inclining the whole frame backward. The correcting straps will need readjustment for proper correcting force when the patient is changed from the upright to the recumbent position.

An effective appliance for corrective jackets in face recumbency is in use at the Boston Children's Hospital, devised by Dr. Z. B. Adams. The apparatus consists of a heavy gas-pipe frame, three by four feet. The patient lies face downward on two webbing strips, running from end to end of the frame, with the legs flexed. Near the bottom of the frame is an adjustable crossbar bent to fit into the flexure between the

thighs and the pelvis, on which the patient rests the lower part of the body. Sliding on this bar are two arms, which slide in and clamp down on the buttocks, holding the pelvis steady on the crossbar. This bar

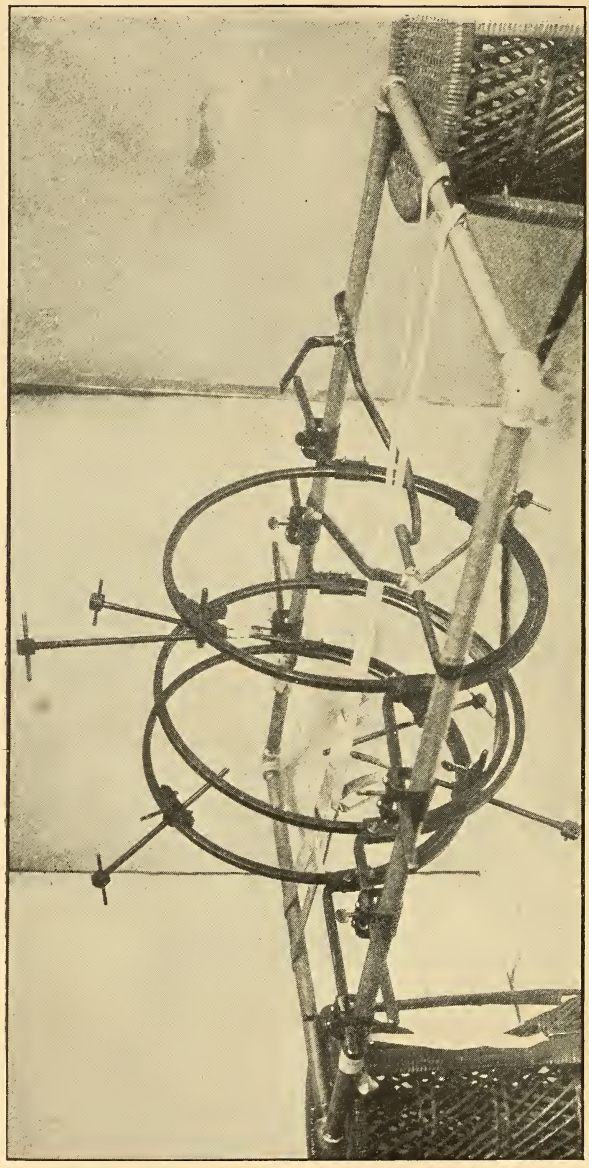


FIG. 327.—Apparatus for the Application of Plaster Jackets in Recumbency.

is movable from side to side in order to induce or correct curvature in the lumbar region when necessary. There are three vertical transverse rings, two feet in diameter, fastened to pieces on the sides of the frame

so that they can be moved to any desired point along the frame. These rings are also movable from side to side, and by an independent movement they can also be rotated through a half circle. Any one of these movements can be checked at any point by turning a screw. The shoulders are held by a pair of axillary straps fastened together by a

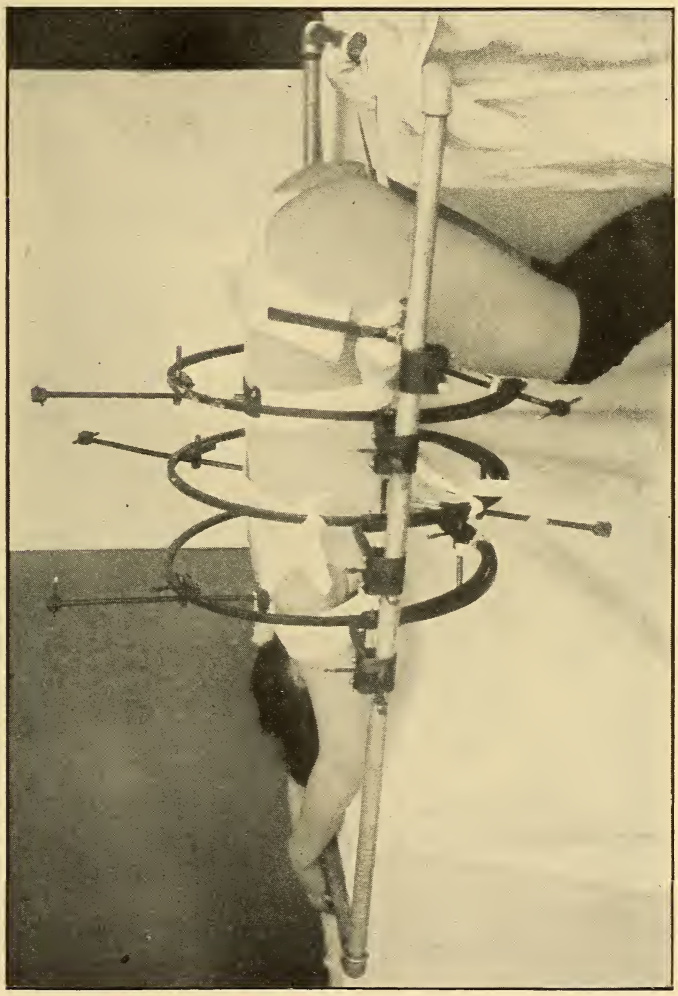


FIG. 328.—Apparatus Shown in Fig. 327 in Use Ready for Application of Plaster Jacket.

strap across the chest in front. These straps are suspended from the ring nearest to the top of the frame and can be made to hold the shoulders in any desired degree of twist by a rotation of the ring.

Each ring is provided with two long screws at the two poles of the ring. These screws are adjustable upon the ring and can be set at any desired angle to it. By rotating the ring and adjusting the angle of the

screws they can be made to screw down or up upon any part of the back or chest.

For the application of the jacket the patient lies on the face on the two webbing strips, the lower part of the trunk resting on the cross rod and the bars clamping the buttocks; the feet rest on the floor and the arms are extended above the head. The rings are then adjusted at the two levels where it is desired to make correction, generally in the dorso-lumbar and the dorsal regions. For side correction a webbing strap is fastened to one side of the ring, carried around the patient's side over

FIG. 329.—Lateral Curvature Before Correction.

FIG. 330.—Lateral Curvature Three Weeks After Correction.

a heavy pad of felt and back to the ring. The same is done to the other ring at the other level where side correction is desired, while the top ring controls the shoulders. The rings are then pulled to one side, the bandages around the patient tighten, and any endurable degree of side correction is obtained.

When the side correction is made the screws are then screwed down on to the patient, their points being protected by sheet-iron pads, two by three inches, which are covered with heavy felt. These pads are incorporated in the jacket.

The shoulders are controlled by the axillary pads attached to the upper ring along with screw pressure up or down as desired. In the correction each level is separately attacked from below upward.

A plaster jacket is applied to the patient held in this way with a great amount of force at the operator's disposal.

In applying corrective jackets it is to be remembered that there are two elements of the deformity demanding correction—one, the lateral curve, to be corrected by side force; the other, the rotation, to be corrected by a twisting force. Any use of force, to be effective, must be

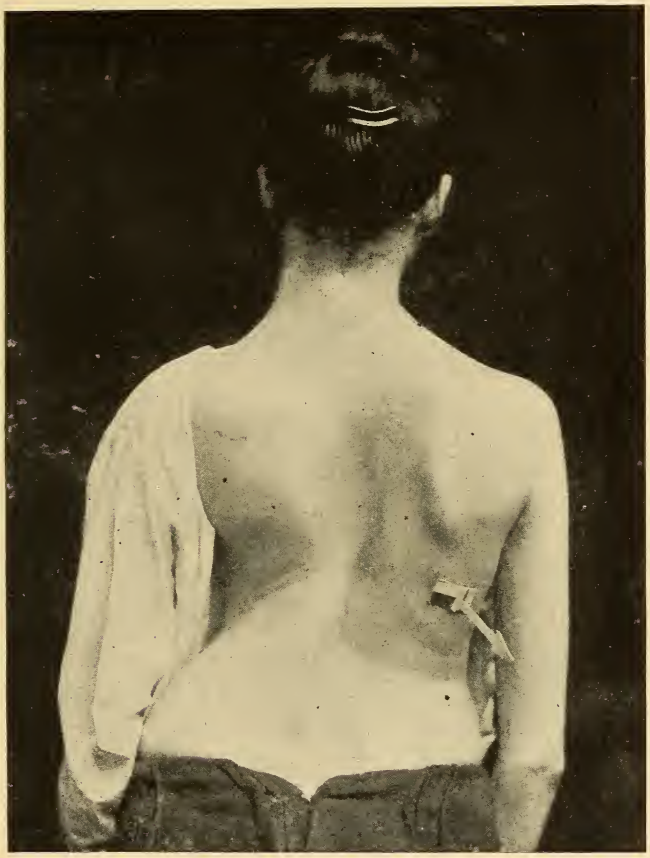


FIG. 331.—Case of Scoliosis before Operation Showing Lateral Deviation of Spine. (Michael Hoke.)

met by counter-points of resistance or the whole spine will be pushed to one side or twisted as a whole.

High dorsal curves are not likely to be much improved by corrective jackets, because no satisfactory point of counter-pressure can be found above the curve. Lumbar curves are also generally better treated by other means, because there are no ribs to exert side pressure on this region and direct side force cannot be exerted.

Corrective plaster jackets should embrace the shoulders and, in cases of high dorsal curves, the neck, and should not be removable. Windows can be cut in the jacket over the portion of the trunk where pressure is undesirable. At first the patient will need supervision, but later can go about freely. Jackets should be repeated at short intervals, preferably two or three weeks, and applied as long as cor-

FIG. 332.—Case of Scoliosis Before Operation Showing Rotation. (Michael Hoke.)

rection can be obtained. This stage of treatment is followed by that of removable jackets and gymnastic exercise.

The amount of correcting force used is a matter of judgment, as is also the time when corrective pressure treatment should be discontinued. Supporting jackets are necessary for many months after correction has stopped, and should be discontinued gradually.

ADULT CASES.—When the bones have become hardened by growth, marked correction is not possible either by intermittent or by constant pressure. The treatment must be palliative and consist of gymnastics, massage or electricity to relieve symptoms, accompanied or not, ac-

cording to circumstances, by corsets as a partial support to superimposed weight.

Treatment by Operation.

Operative attempts consisting of resection of the projecting ribs, performed by Volkmann in 1889 and Hoffa[1] in a few instances, have been made in cases in which the distortion of the ribs resulting from

Fig. 333.—Case of Scoliosis After Operation. (Michael Hoke.)

rotation is so severe as to preclude the possibility of correction by other means. The success obtained was not great.

Hoke[2] has utilized this method, carefully executed, as a preliminary to later jacket correction, on the theory that in some cases with marked distortion of the thorax the ribs constitute an impediment to correction of the rotation. The success obtained by Hoke was satisfactory in the case in which the treatment was reported.

[1] Zeitsch. f. orth. Chir., 1896, 401.

[2] Amer. Jour. of Orthop. Surgery, vol. i., No. 2.

Braces and Corsets.—Treatment by the use of spinal braces and spinal corsets alone, other than the temporary use of plaster jackets applied under corrective pressure, is not advisable. These serve only as an adjuvant to other treatment.

Summary of Treatment.

If the back is flexible and no observable osseous change has taken place and the curvature disappears during suspension or recumbency, the treatment should be postural and gymnastic. The gymnastics should as a rule be "light," symmetrical work. Asymmetrical exercises may form a subordinate part of the treatment. Corsets are needed in the more marked cases where exercises alone do not effect improvement.

When the curve is somewhat fixed but fair flexibility remains, the treatment should consist of corrective stretching by gymnastics or appliances and heavy and light symmetrical gymnastics. Supports will be required under the same conditions as those mentioned for flexible cases.

In structural cases with rigid curves, gymnastics are of use only as an adjuvant, and corrective force intermittently exerted by appliances and gymnastics or continuously exerted by means of corrective jackets are the modes of treatment to be considered. The latter is the proper method for the severer cases. Severe structural cases have been operated upon with fair success. Severe structural cases in adults are best treated by support, massage, and exercises to secure a better general carriage.

The length of time needed for treatment varies necessarily. In general it may be stated that growing children with a tendency to faulty attitude need careful inspection during the years of growth. The inspection need not be frequent, and will vary from three months to six months according to the rate of growth. In light cases a few weeks' supervision of gymnastics, followed by monthly or quarterly inspection, is all that is necessary. In severer cases the treatment will require at first frequent attendance and later, observation for a period of months followed by inspection at longer intervals.

CHAPTER XII.

OTHER DEFORMITIES OF THE SPINE AND THORAX.

Kyphosis (Round shoulders.—Causes.—Symptoms.—Prognosis.—Treatment).—Lordosis.—Spondylolisthesis (Pathology.—Etiology.—Symptoms.—Treatment).—Deformi[illegible] reon Breast.—Funnel Chest.—Con- n of the Scapula.

ght and does not present the

s the child attempts to sit and the others in that it can be of the head, while the other at least, permanent.

e habits, occupation, muscular . The normal curves are for- the dorsal, and forward in the

e are set by the shape of the nd the tonicity of the muscles. eruse, by too rapid growth, or ghly to do the work expected these curves. The spine is position,[1] and the amount of to the accompanying table of ople standing, and their length s; ten of these were adults and latively greatest in the child.

		rect	Length in Dorsal Recumbency.	Difference.
		n.	5 ft. $9\frac{1}{4}$ in.	$\frac{2}{16}$ in.
		V.	6 " $2\frac{1}{16}$ "	$\frac{11}{16}$ "
		"	5 " $8\frac{1}{16}$ "	$\frac{7}{16}$ "
		$\frac{3}{16}$ "	5 " $1\frac{1}{16}$ "	$\frac{14}{16}$ "
		8 "	5 " $8\frac{1}{16}$ "	$\frac{10}{16}$ "
		$8\frac{12}{16}$ "	5 " 9 "	$\frac{4}{16}$ "
		5 " $11\frac{14}{16}$ "	6 " $\frac{4}{16}$ "	$\frac{6}{16}$ "
		5 " $11\frac{2}{16}$ "	5 " $11\frac{2}{16}$ "	$\frac{4}{16}$ "
9.....	31	6 " 2 "	6 " $2\frac{12}{16}$ "	$\frac{12}{16}$ "
10.....	35	5 " $4\frac{13}{16}$ "	5 " $5\frac{5}{16}$ "	$\frac{8}{16}$ "
11.....	$3\frac{1}{2}$	3 " $1\frac{8}{16}$ "	3 " $2\frac{4}{16}$ "	$\frac{12}{16}$ "

[1] T. A. Storey: Am. Phys. Education Review, 1904.

The term *kyphosis* is used to designate an increase in the backward dorsal physiological curve, and the term *lordosis* to describe an increase in the forward physiological curve in the lumbar region.

KYPHOSIS.

An increase of the backward curvature of the spine, being an exaggeration of the dorsal curve, is most noticeable in the upper part of the spine, although it may practically involve the whole column. It occurs

FIG. 334.—Round Shoulders. Curve of dorsal and lumbar regions. Marked forward displacement of shoulder.

(1) as a static deformity, which is the commonest form seen, and is known as "round shoulders"; or (2) as the result of an abnormal condition of the bones or as a result of paralysis.

1. Round Shoulders.

The term round shoulders is generally applied to the stooping attitude which results from the muscular relaxation due to rapid growth, to the assumption of improper attitudes, and to poor general condition.

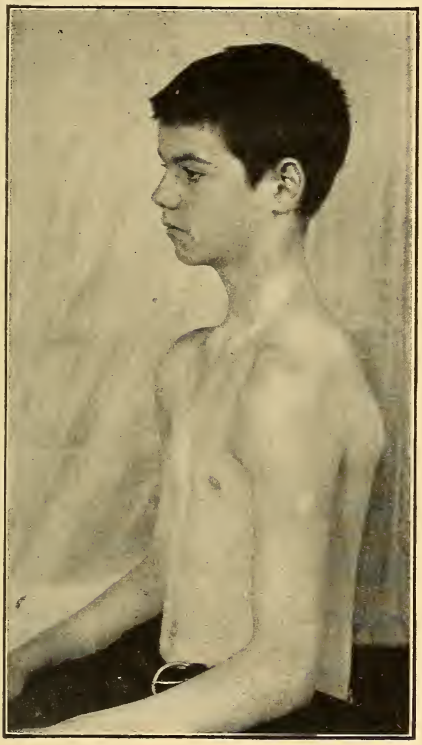


Fig. 336.—Round Shoulders with Forward Displacement of Scapulæ. Back comparatively flat.

Fig. 337.—Round Shoulders with Increased Lumbar Lordosis.

It is generally seen in children and is likely to be observed at any time after the age of five or thereabouts.

Causes.—The affection is to be regarded as a static one connected with improper muscular support. The common causes are as follows:

Improper position at school and at home. The stooping position necessitated by improperly fitted school furniture used, by the attitude assumed in writing, and the curled-up position assumed by children in reading at home are important factors in the causation of round shoulders, and what has been said in regard to the causation of school scoliosis applies equally well to round shoulders.

Rapid growth, long hours at school, insufficient food, improper

arrangement of clothing, and too long an active day are causes inducing muscular debility and therefore favoring round shoulders.

Symptoms.—The attitude of round shoulders is well known and the name itself is descriptive. The head is not carried erect, but is run forward somewhat, the shoulders slope forward, the scapulæ are unduly

FIG. 338.—Sitting Position in Marked Round Shoulders. The spine is flexible and can be straightened by muscular effort.

prominent behind and may be noticed through the clothing in severe cases, and the whole shoulder-joint seems to be forward of its normal position, the chest is narrow and flattened, and the expansion deficient. The lumbar spine may present an increased forward curvature, so that the patient stands with an abnormally hollow back, or the lumbar spine may be involved in the backward curve and the lumbar curve diminished or lost. The patient's trunk is carried back and the abdomen thrust forward. The pelvis is forward of its normal position. Some degree of flat-foot is likely to coexist, and beginning lateral curvature accompanies many of the cases.

With the persistence of the attitude of round shoulders the muscles and ligaments in front of the shoulders become shortened and those at the back stretched. The muscular development is generally poor. If

the arms are carried to a vertical position above the head, it is done by arching the spine forward in the lumbar region, which is made necessary by the contraction of the muscles connecting the arms and upper chest, such as the pectoral muscles. Pain is not often complained of, but may be present in nervous children, especially girls.

The attitude may be partially corrected temporarily by the voluntary muscular effort of the patient, but the faulty attitude will be again assumed almost immediately, as the muscles are unable to maintain the corrected position.

The types of variation in the physiological curves of the spine are described[1] under four heads: 1. Flat back. 2. Flat hollow back. 3. Round back. 4. Round hollow back. The first two are rather individual variations from the normal of no especial significance, and will be understood from the figures. The last two are the two variations roughly grouped as round shoulders.

Prognosis.—The prognosis without treatment is not good, so far as recovery from the deformity is concerned, and it may be carried over into adult life practically unchanged. With proper treatment recovery is to be expected.

Treatment.—In the treatment of round shoulders the patient should, of course, be put in the most favorable surroundings possible. Incorrect

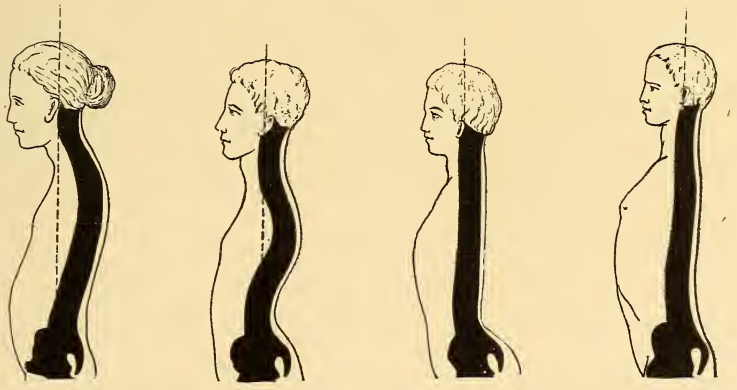


FIG. 339. Round Back. FIG. 340. Round Hollow Back. FIG. 341. Flat Hollow Back. FIG. 342. Flat Back.
(Modified from Staffel to show only upper part of figure.)

attitudes at school and at home should be corrected so far as possible. Errors in vision are to be investigated and remedied if they exist. Undue fatigue and a very long active day are to be avoided.

[1] Staffell: "Die mensch. Haltungstypen," etc., Wiesbaden, 1889.—See Lovett: "Round Shoulders," etc. (with literature). Boston Med. and Surg. Journ., November 6th, 1902.

Arrangement of Clothing.—It is a common custom to fasten a child's clothes, including the garters, to a waist which is kept from slipping down by two straps over the shoulders. These straps do not pass over the root of the neck, but most often over the tips of the shoulders, where they obtain increased leverage to pull the shoulders

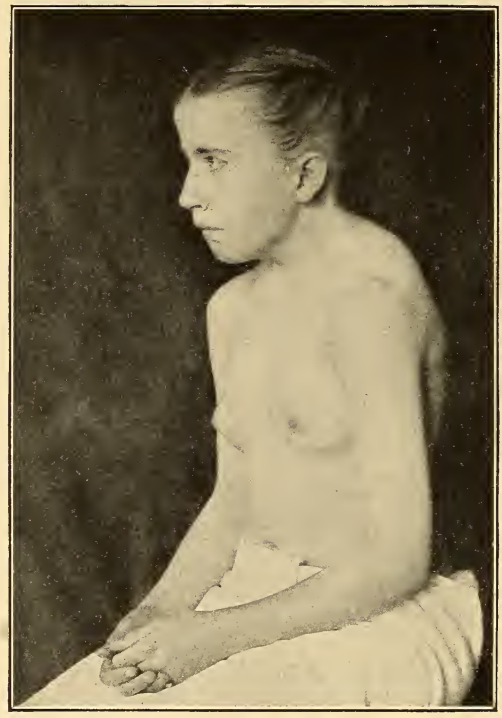


Fig. 343.—Deformity of Shoulders due to the Pressure of Cervical Ribs. (Dr. C. F. Painter.)

downward and forward. The constant drag of this not inconsiderable weight upon structures little suited to support it is a most important factor. The arrangement of clothing should be improved and round garters should be worn, and the stockings should not be fastened to the waist. The trousers and skirts should, if possible, be supported by a belt, and the waist to which the clothes are ordinarily fastened should be relieved of as much weight as possible. The shoulder pieces of the waist should consist of two straps passing close to the root of the neck and not running over the tips of the shoulders. In this way the constant drag of the clothing upon the tips of the shoulders will be avoided. In the more marked cases it is sometimes advisable to use a support of firm webbing, one inch wide, which runs transversely across the back at the level of the axillary line, passes

through the axilla on each side, and over the front of the shoulders, crossing diagonally in the middle of the back. These straps should be sewed where they cross in the back. To the bottom of these straps may be fastened the clothes, if necessary, and their weight will serve in a measure as a somewhat corrective backward pull.[1]

Gymnastics.—The gymnastic treatment of round shoulders consists in stretching the contracted tissues and in drilling the child in the maintenance of a correct position. The stretching can usually be accomplished by simple measures. Suitable exercises for this purpose are as follows:

1. The patient hangs from a bar by the arms.

2. The patient lies on the back with a hard roll under the scapulæ, while the arms are extended and stretched by an assistant pulling them above the head upward and backward.

3. The patient sits on a stool with the hands behind the head and the elbows squared, and the elbows are pulled backward while the knee

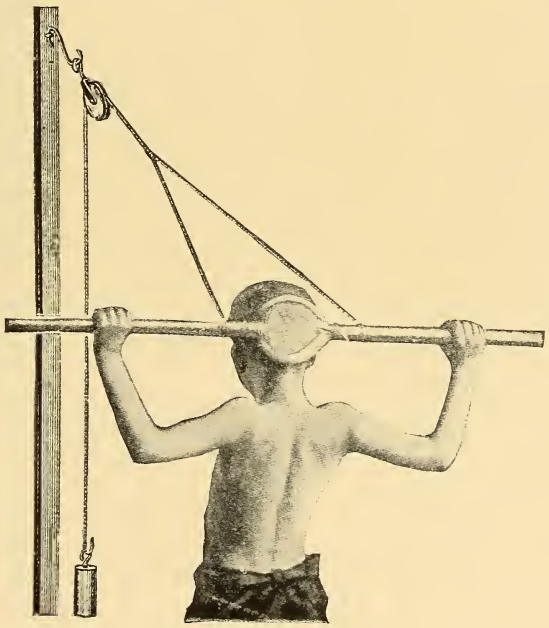


Fig. 344.—Schulthess' Apparatus for Correction of Round Shoulders. (Schulthess.)

of the manipulator presses forward against the spine on a level with the shoulders.

The restoration of flexibility before giving corrective work is essential. The use of a greater degree of force is sometimes necessary to accomplish the desired stretching. This may be accomplished by the

[1] J. E. Goldthwaite: Amer. Jour. of Orth. Surg., vol. i., No. 1, p. 65.

application of plaster jackets[1] covering the shoulders and pulling the shoulders back with any desired degree of force, or by any form of stretching apparatus which pushes the dorsal region forward while holding the shoulders back. As soon as flexibility is restored, postural light gymnastic work directed to the muscles which it is desired to de-

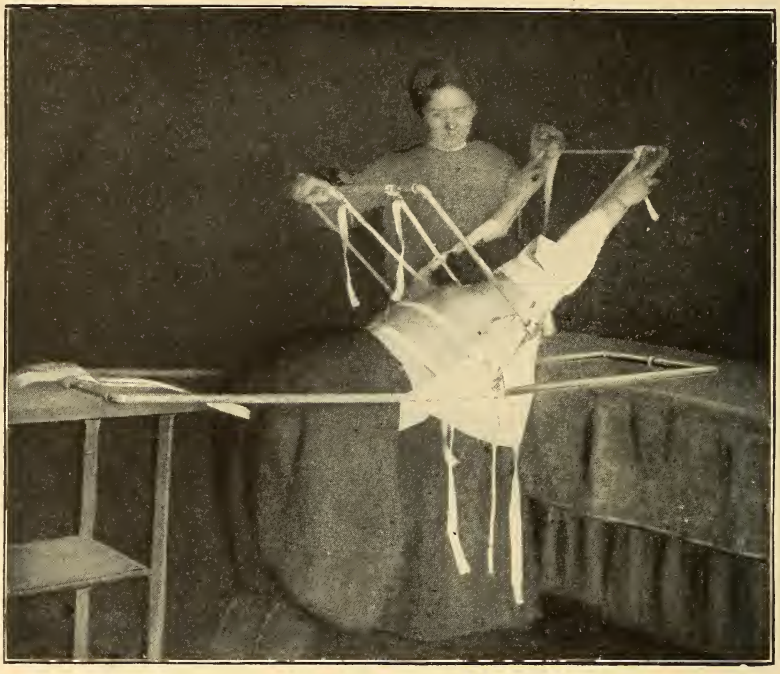


FIG. 345.—Apparatus for Stretching of Round Shoulders.

velop should follow. The demands of the cases are not essentially different from those of early scoliosis so far as the gymnastic treatment goes, the object in each case being to cultivate a correct attitude.

APPARATUS (Chapter XXI., **22**).—In cases of marked round shoulders, when the children are unable to maintain for any length of time a corrected position, some mechanical assistance to the extensor muscles is needed. A useful brace consists of a posterior horizontal pelvic band, grasping the pelvis at the level of the anterior superior spines. From this run up, at a distance of one inch or less from the spinous processes, two tempered steel uprights, which are turned out on the flat at their upper ends and terminate just below the root of the neck well toward the axillary line, where they are furnished with an axillary straps, which run through the arm-pit and fasten to a transverse cross-bar on the brace. This brace is furnished with an abdominal band,

[1] Amer. Jour. of Orth. Surg., vol. ii., No. 3.

which runs from the upright around the abdomen, to assist in the maintenance of the correct position.

A modification of this brace has been made by Thorndike (Chapter XXI., **23**), by adding movable shoulder-pieces, so that the patient has a freer use of the arms.

Static Kyphosis from Occupation.

This type of deformity occurs in adults and in children. In adults it is either the result of a condition acquired in childhood carried over into adult life, or it is acquired by some habitual position connected with the occupation of the individual. It is also seen in workmen who carry heavy loads upon their shoulders. The investigations of W. A. Lane[1] would seem to indicate that the form of deformity caused by occupation is due, not only to a change in muscles and ligaments, but to a real alteration in the shape of the bones. In the same way, as has

FIG. 346.—Patient with Round Shoulders Before Stretching.

FIG. 347.—Patient One Month Later After Treatment by Stretching.

been seen in scoliosis, the persistence of an exaggerated curve of the dorsal spine in a growing child would be likely to lead to a structural change in the bones, resulting in a permanence of the condition. Round shoulders from occupation are noticed in tailors who sit cross-legged with the spine bent, cobblers who bend over their work, clerks

[1] Practitioner, May, 1901.

who sit continually bent over a desk, and in men performing heavy work, such as blacksmiths, who work continually bending over a bench or an anvil. The exaggerated curve of the dorsal spine acquired by children who bend over their desks at school is also to be classed in a measure as an occupation curvature.

Kyphosis may also occur in (2) Pott's disease, (3) spondylitis deformans, (4) scoliosis, (5) osteomalacia, (6) rickets, (7) ostitis deformans, (8) paralysis of the back muscles, (9) old age, acromegaly, and secondary osteoarthropathy.

LORDOSIS.

Lordosis is the name applied to the increase of the physiological curve forward in the lumbar region. This exists in various abnormal conditions, and the amount of curve, of course, varies in normal individuals from those who have a very flat back in the lumbar region to those who have a very markedly hollow back. In certain cases in which the individual is perfectly normal, a very marked lumbar curve exists. It is hardly necessary to do more than mention the various conditions in which lordosis exists.

1. Lordosis often exists in connection with the kyphosis of the dorsal spine spoken of in connection with round shoulders; here it is compensatory to the dorsal curve and the result of muscular weakness.

2. Lordosis also exists in pregnant women and often in persons with large abdomens, due to accumulation of fat or to distention, as in ascites and abdominal tumors. In these cases it is simply the balancing of weight by which the centre of gravity is brought over the centre of support.

3. Increased lumbar curve also exists as the result of training in professional gymnasts, especially in backward contortionists. Such persons habitually walk with a marked degree of lordosis.

4. In conditions in which the abdominal or the back muscles are paralyzed, the attitude of lordosis is the result of an attempt to balance the weight of the upper part of the body without bringing a strain upon the muscles. In paralysis of the abdominal muscles lordosis exists.

5. In Pott's disease of the lumbar region apparent lordosis may be one of the first symptoms to be noticed.

6. In cases of double congenital dislocation of the hip lordosis generally exists, because the point of support of the femur on the pelvis is oftenest back of the acetabulum; consequently the pelvis rotates on a transverse axis, carrying the lumbar spine forward.

7. Lordosis exists in many cases of severe rickets on account of the rotation of the pelvis on a transverse axis, as will be described in speaking of rickets.

8. In hip disease, in which on account of muscular rigidity or adhesions one leg is held in the position of flexion, lordosis is present. In double hip disease with flexion deformity the lordosis may be extensive. Contraction of the hip, for any reason, as in infantile paralysis, causes lordosis.

9. Lordosis may exist in coxa vara, both secondary to the distortion at the hip and as another manifestation of the rhachitic change.

10. In spondylolisthesis lordosis is very marked.

Treatment.—The treatment of these curves is necessarily dependent upon the causative conditions and attendant circumstances.

SPONDYLOLISTHESIS.

The name spondylolisthesis (*σπόνδυλος*, a vertebra, and *ὄλισθήσις*, a gliding) refers to a forward subluxation of the body of one of the lower lumbar vertebræ, with the exception of one recorded case in which the upper part of the sacrum was displaced forward. This displacement has ordinarily been described as a dislocation; in most instances it hardly reaches a greater degree than may be described by the name subluxation. Even this name is incorrect anatomically, because the body of the vertebræ is chiefly affected, while the laminæ and spinous process remain practically in place.[1]

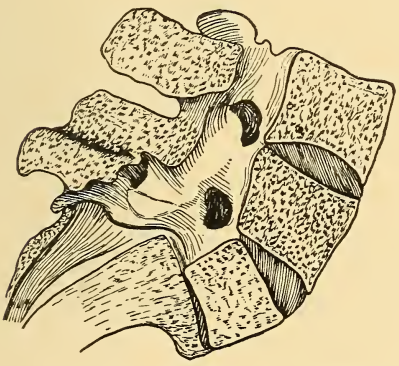


FIG. 348.—Small Pelvis of Prague (Median Section). Instance of slight forward displacement of fifth lumbar vertebra. (Neugebauer.)

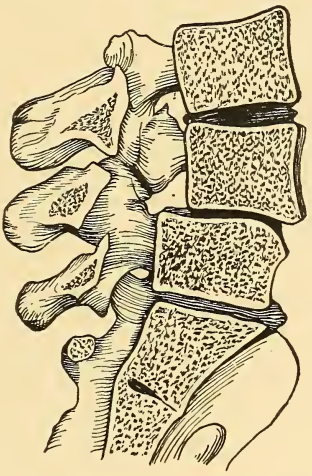


FIG. 349.—Breslau Specimen. Instance of slight forward displacement of the fourth lumbar vertebra. (Neugebauer.)

[1] Neugebauer: "Spondylolisthesis et Spondylizème," Paris, G. Steinheil, 1892. Critical review, description of specimens and cases, complete bibliography.—Killian: "Comment. anat. de Sp.," Bonn, 1853; "Schilderung neuer Beckenformen," Mannheim, 1854.—Blake: American Journal of the Medical Sciences, 1867, cvii., p. 285.—V. P. Gibney: Medical Record, March 30th, 1889.—Lombard: Boston Medical and Surgical Journal, August 20th, 1885.—Lovett: Trans. Amer. Orth. Assn., 1897.

Pathology.—The essential part of the condition seems to be the slipping forward of one of the lower lumbar vertebral bodies, while the vertebral arches remain practically in place. This implies, of course,

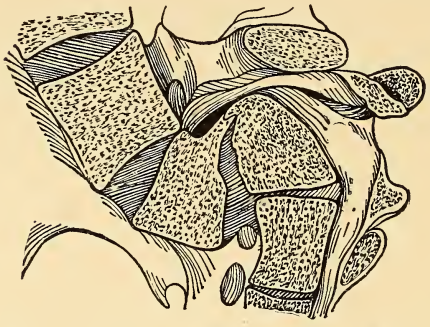


FIG. 350.—Pelvis of Moscow (Median Section). Instance of extreme forward displacement of fifth lumbar vertebra. (Neugebauer.)

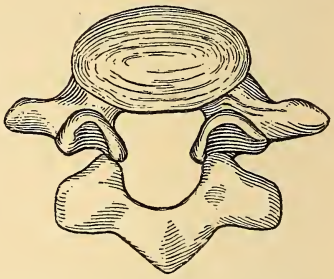


FIG. 351.—Specimen from the Museum of Kölliker at Wurzburg, Showing Double Defect of Vertebral Arch. (Neugebauer.)

an increase in the distance between the body and the spinous process of such a vertebra.

The commonest form of the displacement is subluxation of the fifth lumbar vertebra in relation to the sacrum. The displacement of the

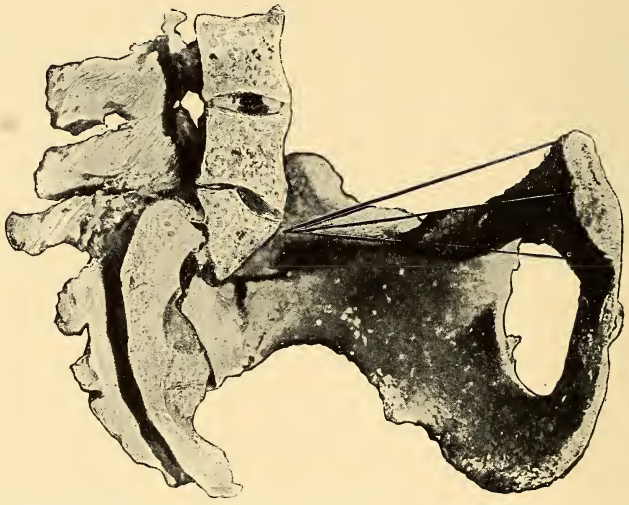


FIG. 352.—Spondylolisthesis due to Vertebral Disease. (Dr. H. B. Cushing, Johns Hopkins Hospital.)

fourth lumbar vertebra in relation to the fifth is next in frequency. The displacement forward of the first sacral vertebra in relation to the rest of the sacrum has been recorded once only (H. von Meyer, Zurich specimen). The displacement may be slight or extreme.

Etiology.—Spondylolisthesis is recorded as affecting women more frequently than men, and comparatively few male cases have been recorded. It occurs almost always at puberty or in young adult life, and the majority of all cases give the account of a severe traumatism, occurring most often during childhood or near puberty. The deformity may follow immediately upon the accident, or it may develop in after-

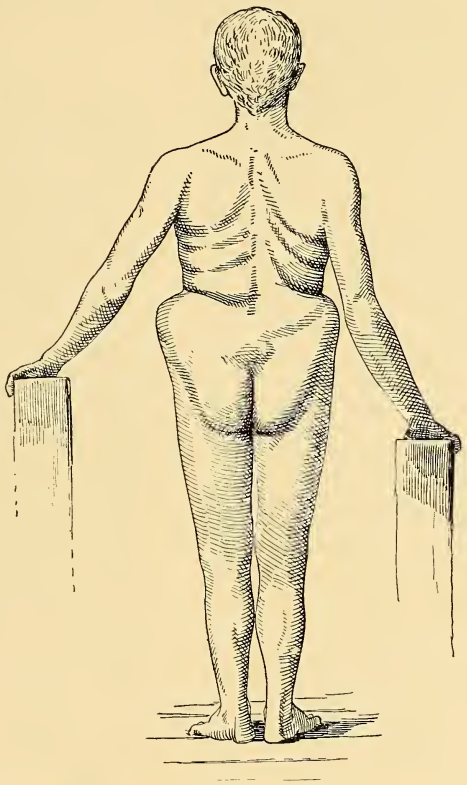


FIG. 353.—Case of Spondylolisthesis. Woman, thirty years old. (Breisky.)

years, just after puberty or during pregnancy. Other cases are to be accounted for only by frequency of pregnancy or by very hard work. In some cases no assignable cause can be found.

Symptoms.—The symptoms by which the diagnosis must be made are as follows: A disturbance of equilibrium resulting in a faulty carriage, which is shown chiefly by a sharp increase in the lower lumbar curve in even the mildest cases. The spine curves forward sharply from the sacrum, and this gives undue backward prominence to the crest of the ilium and the buttocks. The appearance at first glance is the same as that in cases of double congenital dislocation of the hip. Lateral deviation of the spine may be present. With this lordosis goes

a diminution of the obliquity of the pelvis, which causes flexion of the thighs.

Vaginal examination shows, of course, a prominence high up on the posterior wall of the pelvis. The trunk is shortened in relation to the legs on inspection, and the thorax tends to approach the pelvis. The affection is not one characterized by excessive pain.

The differential diagnosis must be made from Pott's disease, double congenital dislocation of the hip, and rickets. Rickets must be recognized by its general diagnostic signs.

Treatment.—The most successful treatment consists in fixation of the lower spine by a jacket or brace until the fracture, if such has occurred, has united and the products of the injury have been absorbed;

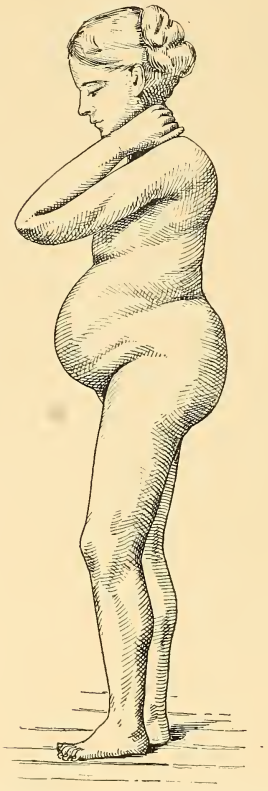


FIG. 354.—Side View of Case of Spondylolisthesis. (Braun v. Fernwald.)

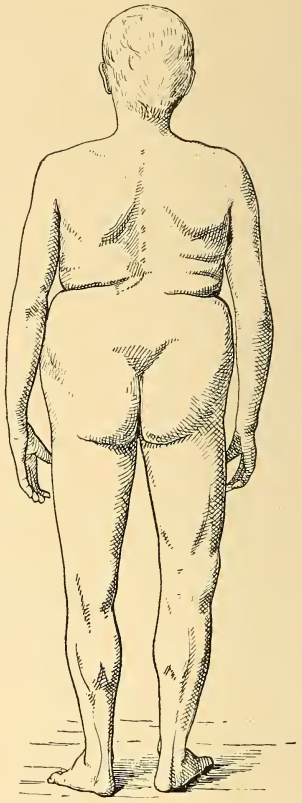


FIG. 355.—Back View of Same Case.

or, if heavy weight-bearing has been the cause, until the stretched and weakened tissues have resumed as normal a position as possible. This period must, of course, last for months, or in cases of great deformity it would seem as if a fixation support must be permanent.

DEFORMITIES OF THE THORAX.

Pigeon Breast (chicken breast, Hühnerbrust, pectus carinatum or gallinatum, poitrine en carène, poitrine de pigeon, etc.) is a deformity more or less common in children, characterized by a prominence of the sternum and cartilages of the ribs and accompanied by an increase in

FIG. 356.—Traumatic Spondylolisthesis in a Young Man of Eighteen.

FIG. 357.—Funnel Chest. (J. S. Stone.)

the antero-posterior diameter of the chest and a diminution in the lateral. The deformity is generally most marked in the median line, but in many cases the prominence affects chiefly the ribs of one side, making a unilateral prominence on one side of the sternum. It is due to rickets and is associated often with nasal or pharyngeal obstruction in growing children. It is also seen in a marked degree in dorsal Pott's disease, in which it is due to the sinking forward of the upper dorsal spine, carrying with it the ribs. In slight cases the deformity is probably outgrown spontaneously, but in the severer cases it may last into adult life.

The treatment consists in children in a combination of gymnastic and respiratory exercises to expand and develop the lateral parts of the chest. As a type of these exercises may be mentioned a useful one, in which the patient lies on the back and, with strong pressure made downward on the deformity, deep inspirations are taken.

Funnel Chest (funnel breast, Trichterbrust, pectus excavatum, thorax-en-entonnoir) is a name applied to a deformity in which the sternum and costal cartilages are depressed below their normal level. The de-

FIG. 358.—Congenital Elevation of the Scapula.

formity is as a rule asymmetrical, and in its lighter degrees is not uncommon. It is more marked in males than in females, and but little is known of the cause of the affection. In many cases it apparently is congenital, and in a mild degree is sometimes seen in connection with Pott's disease. No satisfactory treatment has been formulated beyond general gymnastic measures, among which may be mentioned forced inflation of the chest.

Congenital Deformities.—Other deformities of the thorax of congenital origin need only to be mentioned. Among these are absence or a defective formation of the ribs, a condition generally associated with lateral curvature of the spine, the presence of cervical ribs, and anomalies

or absence of the pectoral and other muscles. Defective formation or absence of the clavicle has been reported, and malformation of the scapula is sometimes seen.

Congenital Elevation of the Scapula (Sprengel's deformity, angeborener Hochstand des Schulterblattes).—This condition is a somewhat unusual congenital deformity, in which one scapula is raised in its relation to the thorax and clavicle and also to the opposite scapula. The scapula is not only raised, but generally so rotated that its lower angle approaches the spine. Scoliosis is likely to exist in connection with it, and in some cases asymmetry of the face and skull has been noted; the affection is rarely bilateral.[1] One or more of the scapular muscles may be absent and bony anomalies are frequent. In one class of cases a bridge of bone connects the scapula and the vertebral column; in another class there is a long piece of bone projecting upward from the superior border of the scapula, but not articulating with or attached to the vertebræ. In other cases there is no bony outgrowth and no deficiency of muscles. In some cases the projecting upper border of the scapula is so noticeable in its elevated position that it is mistaken for an exostosis.[2]

The etiology is obscure. Certain of the cases are evidently to be classed with other congenital malformations. The theory of intra-uterine pressure and the persistence of a position of the scapula natural to a certain period of fœtal life have been urged as the cause of some of the cases.[3]

In cases seen during childhood extensive division of the shortened muscles holding the scapula in its abnormal position is to be advised, and the removal of any bony bridge or projection. Marked improvement may thus be obtained. In older cases no operative treatment is advisable.[4]

[1] Centralbl. f. Chir., 1902.
[2] Wilson and Rugh: Annals of Surgery, April, 1900.
[3] Hibbs and Correll—Löwenstein: Zeitsch. f. Orth., xi., 1, p. 40.
[4] Freiberg: Annals of Surgery, May, 1889.

CHAPTER XIII.

TORTICOLLIS.

Definition. — Etiology.—Pathological anatomy.—Symptoms.—Diagnosis.—Prognosis.—Treatment (Mechanical.—Operative).

DEFINITION.

The name torticollis is given to that distortion of the head which causes it to be held awry, and this condition is either constant or intermittent.

The other names by which this affection is known are wry-neck, caput obstipum, collum distortum, cou tortu, Schiefhals.

ETIOLOGY.

Torticollis may be congenial or acquired.[1]

1. Congenital Torticollis.

(*a*) It may exist in connection with other deformities, such as club-foot and similar malformations. In these cases it seems proper to attribute its existence to those intra-uterine conditions causing other deformities.

(*b*) Abnormal pressure of the uterus seems to be accountable for another class of cases in which the cranium and face on the affected side are smaller at birth.

(*c*) Amniotic adhesions are spoken of as a cause.

(*d*) Inflammation of the muscles seems to be proved by the pathological findings in certain cases and must be mentioned as an occasional cause.

(*e*) Arrest of the development of the muscles due to an affection of the nerves or nerve centres must be spoken of as a cause often advanced to account for torticollis.[2]

(*f*) Rupture of the sterno-mastoid muscle occurring at birth has

[1] Trans. Am. Orth. Assn., iv., p. 293.—P. Redard: "Le Torticolis," etc., Paris, 1898 (full bibliography).

[2] Osler: N. Y. Med. Journ., December 12th, 1891.—Golding Bird: Guy's Hosp. Rep., 1890.—Shaffer: Trans. Am. Orth. Assn., vol. iv., p. 305.

been mentioned[1] as a cause of torticollis, and undoubted cases have been observed where torticollis has followed partial rupture of the sterno-mastoid at childbirth. Experiments, however, upon rabbits producing hæmatomata of the sterno-mastoid gave negative results. Furthermore, torticollis has not followed the hæmatomata from rupture of the sterno-mastoid at birth in a number of cases carefully watched by several observers.

(*g*) Imperfections in the atlas and cervical vertebræ have in some reported cases been the cause of congenital torticollis.

2. Acquired Torticollis.

As the causes of the affection may be mentioned:

(*a*) Cicatricial contraction of the skin or deeper tissues.

(*b*) Traumatism to the neck and head.

(*c*) Dislocation of the upper cervical vertebræ.[2]

(*d*) Inflammation of the muscle (rheumatic torticollis or acute or chronic myositis).

(*e*) Reflex irritation of the muscles in caries of the spine is well known, and in vertebral articular rheumatism this distortion may follow. Torticollis may also be seen in inflammation of the cervical lymph nodes or with deep cervical abscesses, retropharyngeal abscesses, inflammations of the ear, parotitis, adenoid vegetations in the nasopharynx, tumors of the neck, and cerebral lesions. Neuralgia of the spinal accessory or cervico-brachial nerves may be accompanied by torticollis.[3]

(*f*) Difference in the plane or power[4] of vision of the eyes.

(*g*) Lateral curvature.

(*h*) Voluntary habit[5] (physiological torticollis).

(*i*) Occupations in which the overuse of one sterno-mastoid muscle is necessary, as in the case of a factory girl who was continually com-

[1] Jeannel: "Encyc. Int. de Chir.," 1886, v., 777.—Busch: Berl. klin. Woch., 1873, xxxvii.—Stromeyer: "Handb. der Chir.," ii., 4.—Fischer: Deutsch. Chir., 1880, Lief. 43.—Volkmann: Cent. f. Chir., 1885, xiv., 233.—Witzel: Deutsch. Zeit. f. Chir., 1883, xviii., 534.—Petersen: Zeitsch. f. orth. Chir., i., L. 1, 113.—Fabry: Inaug. Diss., Bonn, 1885.—Cent. f. Chir., 1895, No. 1.—Deutsches Arch. f. Chir., 1882, p. 181; Cent. für Gyn., 1886, No. 9.—Bouchut: "Traité Prat. de Mal. des Nouv. Nées," Paris, 1750.—Archiv f. Kinderheilkunde, 1891, Bd. xii., 5 and 6.—N. Y. Med. Rec., February 27th, 1886.—Petersen: Cent. f. Gyn., 1896, No. 48.

[2] Walton: Bost. Med. and Surg. Journ., cxlix., 17, 445.

[3] Dollinger: Pester med. chir. Presse, 1889, No. 48.

[4] Bradford: Trans. Am. Orth. Assn., 1889, vol. i., p. 46.—Lovett: Trans. Am. Orth. Assn., 1889, vol. i.—Gould: American Medicine, March 26th, 1904.—H. W. Kilburn: Boston Med. and Surg. Journ., March 24th, 1904.

[5] Mellet: "Manuel Prat. d'Orth.," Paris, 1844.

pelled by her work to turn the head to one side, or in the case of a person carrying heavy loads continually on one shoulder.

(*j*) Rickets.

(*k*) Pott's disease of the cervical vertebræ.

(*l*) Injury to the nerve centres at the time of birth. The affection may rarely involve both sides, as in a case figured by Whitman.[1]

(*m*) Paralysis of the spinal accessory nerve from such causes as rheumatism or trauma as well as anterior poliomyelitis[2] and the muscular dystrophies.[3]

Spasmodic Torticollis.—In this class are included those cases which arise from nerve irritation. This form may be central and occur in the distribution of the spinal accessory nerve, or it may be the local manifestation of a more general nervous irritation as in spinal irritation. In some cases of the spasmodic form, the affection is closely allied to writers' cramp, spasmodic tic of the face, etc., and in one case observed there was a nodding motion to the head. The spasm in this class of cases can be either tonic or clonic.

Frequently no definite cause can be found to explain the occurrence of this form, but it is evidently the result of general malnutrition or general nervous disturbance having this as a local manifestation. Not infrequently in these cases there will be found a definite exciting cause, such as fright, grief, etc. In this class might be included the "torticolis mental" of Brissaud[4] and Bompaire.[5]

Many of the above causes seem each to be but one out of many factors. In a large percentage of cases there will be found to be a neurotic family or personal history; also the general condition seems to have a very considerable influence. Many cases occur after severe overwork, in this particular bearing a close analogy to professional cramp or spasm.

PATHOLOGY.

The pathological condition existing in congenital torticollis has been demonstrated by autopsy and by pieces of muscle removed at operation. In some instances the contracted muscle appears normal, but more often the muscular substance is replaced by fibrous tissue. This may occur in small patches[6] or the whole muscle may be transformed into a tendinous band. In the majority of cases of fibrous degeneration of the muscle it is adherent to the sheath, and in some instances muscle and sheath are fused in one fibrous band.

[1] Bradford and Lovett: "Orth. Surg.," 2d ed., p. 632, Fig. 272.
[2] Hoffa: "Orth. Chir.," 4th ed.
[3] Dejerine and Flandre, quoted by Redard: "Le Torticolis," 1898, p. 40.
[4] Union Médicale, 1894, p. 161.
[5] "Torticolis Mental," Thèse de Paris, 1894.
[6] Volkmann: Cent. f. Chir., 1885, No. 14.—Vallert: *Ibid.*, 1890, No. 38.

The sternal part of the muscle is more often involved than the clavicular. The changes described are to be classed as fibrous myositis, the reason for which has not yet been formulated. Other muscles besides the sterno-mastoid may be degenerated, and all of the structures on that side of the neck are of course shortened. Changes to be classed as perimyositis have been demonstrated in certain cases.[1] Shortening of the muscle on the affected side may amount to several centimetres.[2]

Secondary changes occur in long-continued torticollis. The most marked is asymmetry of the face; a deviation of the line of the nose from a right angle to the line of the eyes is noticed; furthermore, the distances from the outer point of the two eyes to the outer corners of the mouth are not the same, while the cheek on the contracted side is less prominent and the features on the affected side of the face are smaller than those upon the other side. This asymmetry diminishes if the deformity is corrected early. Asymmetry of the skull may also be found, as well as a diminished size of the cerebral hemisphere[3] on the affected side. The carotid artery of the affected side has been in certain cases found smaller.[4]

This asymmetry of the face may occur in acquired torticollis, and it may be present at birth in congenital cases. It may, on the other hand, be present at birth without the existence of torticollis.

Lateral curvature of the spine will result from long-continued torticollis, and a difference in the length of the clavicles has been noted.

SYMPTOMS.

Acute Torticollis.—In the acute form the history is that of an acute muscular rheumatism with some constitutional disturbance and sudden onset with a great deal of pain on movement of the head, and the head is held to one side. The acute stage, however, lasts but a short time and, in general, pain in wry-neck is not a permanent symptom. The chief discomfort from wry-neck is the disfigurement which is always noticeable and never to be concealed. The position assumed by the head is more or less typical and is described farther on. The chronic form may develop from the acute form.

[1] Archiv. d. Pédiatrie, 1890, No. 1.

[2] Orth. Trans , iv., p. 305.

[3] Greffie: Montpellier Méd , November 16th, 1890.—Broca: Bull. Méd., 1894, No. 42, p. 493.

[4] Osler: N. Y. Med. Journ., December 12th, 1891.—Golding Bird: Guy's Hosp. Rep., xlvii., 1890.—Krummacher: Cent. f. Chir., 1889, No. xii.—Beely: Zeitsch. f. orth. Chir., Bd. ii.—Meinhard Schmidt: Cent. f. Chir., July 26th, 1890.—Falkenburg: Deutsch. Zeit. f. Chir., 1885, xix., 338.—Bouvier: "Leç. Clin. sur les Mal.," etc., Paris, 1858.—Stromeyer: "Handb. der Chir.," ii., p. 4, 1864.

Congenital Torticollis.—The position held by the head varies necessarily with the muscles affected. When the sterno-cleido-mastoid is attacked, the ear of the affected side is brought near to the sternum and the face slightly rotated to the opposite side. If the trapezius or posterior muscles are also affected, the head will also be drawn back, the chin elevated above its normal level, and the features on the side of the spasm drawn below those on the opposite side. In addition to these muscles, the platysma, the scaleni, splenii, and other deep muscles of the neck are sometimes affected, and modify more or less the position of the head. The attitude is sometimes so peculiar as to render it difficult to determine exactly what muscles are affected. On palpation certain muscles will be found to be hard to the touch and others flaccid. Rotation of the head is free up to a certain limit, varying in extent. It is not possible to move the head in a direction against the contraction or spasm, and a persistent effort may cause considerable pain.

Spasmodic Torticollis.—The intermittent form of torticollis is not infrequent. It is due to imperfect muscular balance from overstrain of certain groups of muscles which are affected by spasmodic attacks. This condition is not unlike that noted in writers' cramp and similar

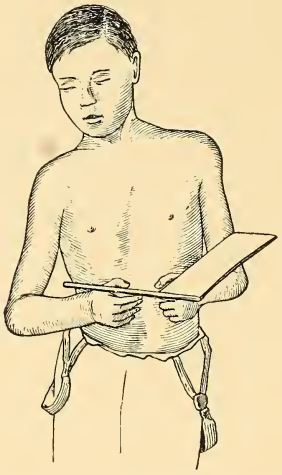


FIG. 359.—Ocular Torticollis. Habitual position of head.

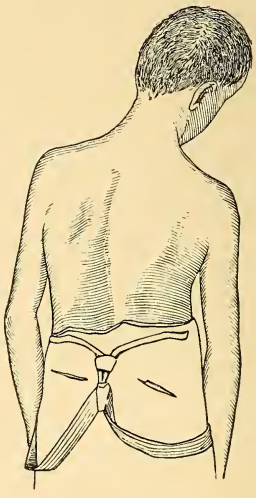


FIG. 360.—Ocular Torticollis; Back View. Habitual position.

muscular disturbances seen in occupation neuroses. At times the head can be held in a proper position, but locomotion or any excitement or the apprehension of being observed may produce such a contraction of the head that it will be twisted violently to one side and rotated to an extreme limit. A slight pressure of the hand steadying the head

will ordinarily correct it, but when the muscular contraction becomes excited, great force is required to hold the head in place. In some cases the contraction may be slow and steadily increase to its maximum. In a recumbent position the contraction does not ordinarily take place. It usually disappears during sleep. The spasm is sometimes tonic and

FIG. 361.—Torticollis Showing Contraction of the Right Sterno-mastoid.

FIG. 362.—Torticollis due to Cervical Pott's Disease.

sometimes clonic, and sometimes pain is excited by the muscular contraction. It is usually confined to the muscles of one side (tic giratoire). It may be accompanied by severe attacks of pain, and may involve the muscles of the back. Slight twitchings of the muscles are sometimes observed for some time previous to an outbreak of the spasmodic condition.

DIAGNOSIS.

There is no difficulty in recognizing the deformity called wry-neck. The head is twisted to one side, the chin being to the right or left of the sterno-clavicular notch, while the face is turned to one side and partly upward. The shoulders are held obliquely to the trunk, twisted, in order to bring the face so far as possible in a vertical line. Certain of the muscles, frequently the sterno-cleido-mastoid, are felt hard on palpation; some rotation of the head is possible, but perfectly free rotation of the head is checked by the contracted muscles.

A diagnosis of the cause and situation of wry-neck is more difficult,

as well as an attempt to distinguish it from other affections which give rise to this malformation, a matter which is of great importance. Such are disease of the cervical vertebra, enlarged cervical glands, cervical abscess, and stiff neck from ordinary cold.

The diagnosis between anterior and posterior torticollis (or torticollis due to contraction of the anterior muscles, chiefly the sterno-cleido-mastoid, and that due to the contraction of the posterior muscles, the trapezius and splenius capitis, etc.) is to be based on palpation chiefly.

Palpation also, with a clinical history of paralysis and the evidence of paralysis elsewhere, is sufficient usually to determine the diagnosis of paralytic torticollis.

Torticollis dependent upon enlarged and inflamed glands can usually be recognized by the evidence of glandular enlargement.

There is ordinarily little difficulty in recognizing the common acute wry-neck. Its course is acute, the deformity appears suddenly, and it is usually accompanied by pain. Improvement is to be noticed in a comparatively short time.

For the diagnosis of congenital torticollis from that due to Pott's disease the reader is referred to the chapter on Pott's disease, but it may be said that in the latter there is greater rigidity, and this involves all the muscles of the neck, and particularly the posterior groups. The pain elicited by attempts to twist the head is greater. When a patient with cervical caries attempts to lie down or turn over the head is instinctively steadied with the hand, while in true torticollis this is not so constant a symptom.

Cases of posterior torticollis, *i.e.*, that form described by Delore, involving the posterior muscles of the neck, resulting from vertebral rheumatism, is rare. It can be recognized by the absence of contraction of the sterno-mastoid and the history of the case.

PROGNOSIS.

The acute idiopathic wry-neck due to muscular inflammation runs a short course and tends naturally to recovery, though in a few cases it may become chronic. Torticollis due to abscess of the cervical glands terminates with the complete discharge of the abscess as a rule. Intermittent spasmodic torticollis may become cured spontaneously, or may, as is more common, remain without change for many years. Congenital forms of torticollis and the common acquired form (associated with muscular contraction which has become chronic and developed fibrous muscular degeneration) demand surgical intervention. No constitutional disturbance follows this affection, which is more distressing on account of the unsightliness than from any actual discomfort.

The deformity is one which is eminently curable by surgical intervention. Complete correction and permanent cure are possible in all cases except in the intermittent form, which is dependent upon a general depressed state of the nervous system, in which a cure cannot always be promised.

TREATMENT.

In acute torticollis due to the inflammation of the muscles, the treatment is largely the alleviation of the symptoms. This is best done by the application of moist heat. Rest of the head and antifebrile constitutional treatment are of course advisable when there is any fever.

Torticollis due to cervical Pott's disease is treated according to the principles of treatment of that affection, and will disappear with the improvement of the bone disease. Torticollis due to muscular contraction

FIG. 363.—Torticollis Brace, Front View.

FIG. 364.—Torticollis Brace Applied, Back View.

secondary to cervical abscesses or enlarged glands is corrected by the proper treatment of cervical abscess. Torticollis due to an affection of the eye is to be corrected by proper ocular treatment.

Congenital Torticollis.—The treatment of wry-neck due to permanent muscular contraction is either operative, or purely mechanical, or mechanical and operative.

MECHANICAL TREATMENT.—Mechanical treatment without the aid of operation is usually unsuccessful or but partially successful, except in the lightest cases.

Massage and passive manipulation are of value in mild cases in connection with mechanical treatment.

A simple form of appliance is that introduced by Buckminster Brown, of Boston (Chapter XXI., **24**). A stiff wire collar passes around the neck, furnished with a plate under the chin, arranged so as to press on the deflected side of the chin. Pressure is also arranged to be applied to the inclined side of the head behind the ear. The wire collar is attached to a ring which rests upon the shoulder, and is furnished with arms which pass down the back.

Mechanical treatment is to be regarded as of value chiefly in retaining the correction obtained by operative measures.

Operative Treatment.—Before the introduction of aseptic surgery the dread of deep suppuration of the cervical fascia certain to follow deep dissection favored the employment of subcutaneous tenotomy of the sterno-cleido-mastoid tendon, followed by mechanical stretching. Failure or imperfect results followed these imperfect methods. Subcutaneous tenotomy is to be rejected as dangerous if freely employed and lacking precision. Open incision of the contracted muscular tissues can be both precise and thorough, and the results are entirely satisfactory.

In the usual form of torticollis the contracted muscle, the sterno-mastoid, is easily attached. Division is made (1) either at the sternal and clavicular insertion, or (2) at its origin at the mastoid process.

Division at the Sterno-Cleido Insertion.—An incision of the skin is made parallel to the clavicle, laying bare the insertion of the muscle. The incision should be sufficiently long to expose the whole attachment, as it is desirable that no undivided fibres remain. It is desirable that the resulting scar, if any, should be concealed below the clothing and not appear in the neck. This can be accomplished by dividing the skin while the head is bent forward, cutting down upon the clavicle and drawing the elastic skin slightly upward from the chest. If, after the division, the head is strongly retracted, as is desirable to give the muscular attachments necessary prominence, the incised skin will gape sufficiently above the clavicle to give room for division of the muscle, aided if necessary by hook retraction of the skin. The tissues to be divided are to be carefully freed from all overlying tissue and a director passed under the sternal tendon, care being taken that the director is passed completely under and not through the muscular attachment.

It is usually necessary that both the clavicular and sternal attachments of the muscle be divided to prevent any possibility of relapse, and for this reason the skin incision should be made sufficiently long to give ample room. With ordinary care there is no danger of dividing the vessels, although they are in close proximity.

The external jugular is so superficial that it can always be seen. It

usually lies farther to the outside than the line of incision. The internal jugular and the artery are separated from the field of operation by the deep fascia, and, if the sterno-cleido muscle is made prominent and stretched by placing the head backward, the muscular insertions can be completely divided without great risk.

In open incision there is danger of wounding the internal jugular vein; deaths from this cause have been reported after tenotomy. The writers would record one case in their experience in which the internal jugular was wounded in an open incision. It was tied and no untoward results followed, the patient making a perfect recovery. The vein lies under the deep fascia, and can be avoided in open incision if the neck be not stretched and care be taken not to open the deep cervical fascia.

FIG. 365.—Result of Open Incision One Year after Operation in a Girl of Sixteen. Shows also the unequal development of the face.

Mastoid Division of the Sterno-Cleido-Mastoid Muscle.—A division of the sterno-mastoid at its origin from the mastoid process has been advocated on the ground that the incision is away from the vessels and that the resulting scar is in a less noticeable region. For this division an oblique skin incision is made along the sterno-mastoid, beginning behind the ear and extending nearly to the middle of the muscle. The muscular origin is much thicker than the clavicular insertions and care will be needed to divide the muscle thoroughly. The muscle is also divided through an oblique incision along the lower third of the muscle. The incision should be a free one if the division is complete. The muscle is thick in this region, but, being prominent and superficial, is easily separated from other tissues.

The choice as to incision will rest with the judgment of the surgeon. The division of the sternal and clavicular attachment appears to have certain advantages, in that the muscle is more nearly tendinous than in the other portions and can therefore be divided more satisfactorily.

Whatever incision is employed, especial care should be taken to promote the healing of the skin. A buried skin suture should be em-

ployed, and the wound protected by silver foil from the irritation of the dressing.

The neck and chest are covered with sheet wadding and the head is fixed in an overcorrected position by plaster bandages applied around the head, shoulders, and thorax. A window can be cut over the incision for the examination of the wound, but under proper precautions the wound can be expected to heal rapidly and to need no further dressing. It is unnecessary for the patient to remain in bed longer than a few days, if satisfactory plaster fixation is furnished. Under some circum-

FIG. 366.—Posterior Torticollis Before Forcible Straightening.

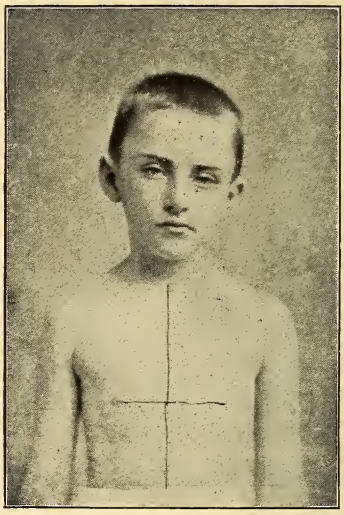


FIG. 367.—After Operation.

stances, however, it is desirable to avoid a cumbersome plaster helmet, and recumbency for two weeks is preferred. It is necessary that thorough overcorrection should be furnished during the period of healing. This can be accomplished by securing the patient on a gas-pipe frame, with the shoulders firmly fastened. Three strips of adhesive plaster with a long strip of webbing sewed to one end of each are applied to the patient's head—one across the forehead, with the tape arranged to pass under the head; a second on the side operated upon, with the tape passing over the head; the third on the opposite side, with the tape passing under the chin. If light weights are attached to the ends of the tapes and pass over sand bags placed at the sides of the face, a correcting pulling force can be exerted in three directions—one pulling the chin to the side not operated upon, the second inclining the long axis of the head in a direction the reverse of its former inclination, and the third rotating the face toward the unaffected side. This method of fix-

ation will be found of use where it is difficult to secure the adequate amount of overcorrection of the deformity at the time of operation. It should be borne in mind that not only correction but overcorrection, at or immediately after the operation, is necessary to prevent a relapse, which will follow to a greater or less degree if contracted tissues remain.

After the wound is entirely healed the patient should wear, for from three to six months, a retaining appliance holding the head in an overcorrected position. This can be a plaster bandage, a leather moulded on a plaster form, or a steel appliance (Chapter XXI., **24**).

Massage will aid in the recovery of muscular tone.

The results of the correction of torticollis by open division are extremely satisfactory. The asymmetry of the face becomes more noticeable after correction than it was in the deformed position, but in children disappears gradually if the corrected position is retained. Resection of the lower two-thirds of the sterno-mastoid muscle has been advocated, on the ground that after-treatment is shortened and relapse prevented. It seems unnecessary, however, as it leaves a long scar, and as simple division and proper after-treatment are efficient in correcting the deformity.[1]

Posterior Torticollis.—Besides the deformity largely associated with contraction of the sterno-mastoid muscle—anterior torticollis—another form is seen, as has been already mentioned, viz., posterior torticollis. This variety constitutes a class of obstinate cases. The only efficacious treatment is that of forcible correction without tenotomy, for the reason that, as a rule, the muscles are too deep or extensive to be tenotomized. The writers have divided the outer bands of the anterior scalenus and trapezius by open incision and can report the feasibility of the procedure. In correcting this deformity the patient should be thoroughly anæsthetized, and an assistant should hold the shoulders firmly, while the patient should be so placed that the head projects beyond the end of the operating-table. The head should be held by the hands of the surgeon and rotated in all directions, considerable force being used. The danger of fracturing the spine is in such cases, of course, so slight as to be disregarded, and the deformity can be overcorrected. After the operation the head should be fixed, the after-treatment resembling that of the ordinary torticollis.

Spasmodic Torticollis.—Great difficulty is met in the treatment of spasmodic torticollis as compared to the congenital torticollis, from the fact that the constitutional nature of the affection (due to impaired nervous condition) is an important factor to be considered. The affection may be considered a localized chorea or a disturbance of the proper muscular balance of the muscles holding the head. Of the constitu-

[1] Zeitsch. f. orth. Chir., xi., 3, 417.

tional treatment nothing need be said, further than that the success of treatment will depend upon the removal of the patient from all depressing influences, one of which is the distress caused by the unequal muscular action sometimes accompanied by severe pain. The surgical treatment consists of measures of fixation, muscular rest, muscular development, and operative measures. In many instances the irregular action of certain muscles is due to their fatigue from overstrain. The affection may be considered a muscle revolt.

Treatment by Rest and Fixation.—Treatment by absolute rest of all muscles sustaining the weight of the head is indicated. This can be furnished by placing the patient in a recumbent position without pillows and fixing the head by sand bags applied at each side of the head. A plaster bandage can be applied or a moulded leather substitute holding the head, shoulders, and trunk firmly, relieving the muscles from any weight-bearing strain.[1] With this the patient is relieved of the restraint of recumbency. Local applications can be made to the muscles with electricity and massage.

Treatment by Muscular Training.—Great benefit may follow carefully directed and graded exercises.

Treatment by Operative Measures.—The tedious nature of conservative treatment suggests the employment of operative measures. The restoration of muscular balance by myotomy, fasciotomy, and the incident temporary muscular rest is observed in the surgical treatment of muscular spasm in spastic paralysis, and the same principles can be applied in spasmodic torticollis. The muscles involved are not only the sterno-cleido-mastoid, but the various muscles in the back of the neck. Stretching, division, and excision of portions of the nerves supplying these muscles have been employed. Of these procedures the latter (viz., extirpation of the nerves) has been followed with the best result. As this involves a somewhat free dissection of the tissues, it has been suggested that the benefit following the procedure is due more to the dissection and freeing of the contracted tissue than to the paralysis. Kocher advises myotomy and fasciotomy alone rather than nerve resection. Richardson and Walton, however, report good results following the latter procedure.

The nerves to be divided are the spinal accessory from the sterno-mastoid, and a secondary operation on the nerve roots of the deep posterior cervical plexus.

Spinal Accessory Nerve.—This nerve is divided and excised for spasmodic wry-neck. It may be reached anterior to the sterno-cleido-mastoid, an incision being made along the anterior body of the muscle, passing two inches downward from the lobe of the ear. The muscle is

[1] H. J. Hall: Orth. Trans., vol. xi., p. 233.—Boston Med. and Surg. Journ., March 9th, 1899, p. 236

turned to the outside and the nerve can be found a little above the level of the hyoid bone. If it be desirable to reach the nerve, as is possible, from the sterno-cleido-mastoid, the incision is made along the outer border of the muscle, the centre of the incision being the centre of the muscle. The nerve will be found a little above this point.

Division of the Nerves in the Deep Posterior Cervical Plexus.—Keen divides the posterior branches of the first, second, and third cervical nerves in spasmodic torticollis, which has been unrelieved by the incision of the spinal accessory. A transverse incision is made half an inch below the level of the lobule of the ear. The trapezius muscle is divided in the same line. The muscle is then dissected up and the great occipital nerve is found. The complexus is then divided, and the great occipital nerve is followed until its origin from the posterior division is reached. The suboccipital or first cervical nerve is excised. It lies in the triangle close to the occiput formed by the two oblique muscles and the posterior straight muscle. The exterior branch of the posterior division of the cervical nerve is found lower down, and should be divided close to the bifurcation of the main nerve.

The anterior branches of the cervical plexus may be reached by means of an incision along the posterior border of the sterno-cleido-mastoid muscle.

Even after operative intervention careful after-treatment by muscle training is necessary to obtain permanent cure.

In the absence of complete statistics it is impossible to state the absolute relative value of the different methods of treatment. The treatment in obstinate cases needs to be thorough. On the failure of non-operative treatment, thoroughly and persistently applied, operative measures are to be employed. Reasoning from analogy, sections of contracted muscular tissue are as valuable as nerve excision.

CHAPTER XIV.

ANTERIOR POLIOMYELITIS.

Definition. — Etiology.—Pathology.—Symptoms.—Diagnosis.—Differential diagnosis.—Prognosis.—Treatment.

Anterior poliomyelitis or infantile spinal paralysis is an affection which attacks chiefly children. It comes on with a sudden onset and deprives certain muscles and often an entire limb of muscular power, and the parts affected undergo rapid atrophy. The paralysis is a purely motor one.

The pathological name of the affection is acute anterior poliomyelitis, and other common names are: Infantile paralysis, essential paralysis of children, acute atrophic spinal paralysis, "teething palsy" or dental paralysis. Regressive paralysis (Barlow), myelitis of the anterior horns (Seguin), myogenic paralysis (Bouchut). German: Kinderlähmung, spinale Kinderlähmung, essentielle Kinderlähmung. French: Paralysie spinale, paralysie infantile, paralysie des petits enfants, paralysie essentielle de l'enfance, téphromyélite antérieure aiguë (Charcot), etc.

The disease was first mentioned by Underwood [1] in 1784, but it was not then separated clearly from the other kinds of paralysis affecting children, and it remained for Heine to give the first accurate account of the disease in 1840.

ETIOLOGY.

Little is known of the causation of infantile paralysis.[2] The disease is usually limited to the time of the first dentition in children. In 12,694 cases of orthopedic affections in children under twelve seen at the Children's Hospital, Boston, there were 987 cases of anterior poliomyelitis. In 599 cases (Seeligmuller, Galbraith, Sinkler, Gowers, and Starr) 472 occurred before the fourth year, 118 in the first, 214 in the second, 140 in the third, and 52 in the fourth. It has been reported as occurring in a baby four weeks old.[3] The disease has been seen as

[1] "Treatise on the Diseases of Children," London, 7th ed., 1826, p. 251.

[2] Duchenne fils: Arch. gén. de Méd., tome ii., 1864.—Seeligmüller: Gerhardt's "Handbuch der Kinderkrankheiten," v., 1881, p. 1.—Wharton Sinkler: Keating's "Encyclopedia," p. 683.

[3] Schultze: "Lehrb. der Nervenkrankheiten," Stuttgart, 1898, p. 223.

early in life as the twelfth day in a case of Duchenne's, and adults are not exempt from a similar affection.

Exposure to severe heat and sunstroke are mentioned as occasional causes of the attack of paralysis. Most cases occur during warm weather. Twenty-seven of Barlow's 53 cases occurred during July and August, and Sinkler found that in 213 out of 270 cases the disease occurred from May to September inclusive.

An acute feverish attack, like indigestion, is often assigned as the cause, but inasmuch as it may be the chief symptom of the onset, no weight can be attached to it.

Certain other cases seem to come on after a fall, and it is quite possible that a traumatic hemorrhage into the substance of the cord might occur, causing much the same symptoms as anterior poliomyelitis, but such traumatic histories are rare.

As a matter of fact, the disease attacks healthy and unhealthy children, boys and girls alike, usually without any demonstrable cause, coming on in the midst of perfect bodily health, and apparently the affection has no dependence upon a hereditary influence. It is by far the commonest paralysis in children and in most cases develops during the night rather than the day and commonly during the hot months.

Modern opinion rather inclines toward regarding the affection as infectious in origin, although the infecting organism has not been definitely demonstrated. Fresh cases have been investigated as to the presence of a micro-organism, with negative results for the most part. Schultze,[1] however, in a case of what he considered anterior poliomyelitis of the arms and neck in a boy of five, did a lumbar puncture on the thirteenth day, and found in the cerebrospinal fluid withdrawn an organism which he described as the Weichselbaum-Jäger diplococcus. The later history of the case was that of infantile paralysis. As a somewhat similar form of paralysis follows certain cases of cerebrospinal meningitis, this evidence cannot be accepted as conclusive.

The affection occurs at times as an epidemic, which lends force to the view of its infectious character. Such epidemics have been reported from time to time.[2] The earliest was in 1843.[3] Medin[4] reported 44 cases occurring in Stockholm in the summer of 1887. There were three deaths, and although in general the ordinary type of infantile paralysis was followed, a few aberrant cases were seen. Briegleb[5] reported an epidemic in 1890.

[1] Münch. med. Wochenschr., 1898, No. 38, p. 1197.
[2] Painter: Orth. Trans., vol. xv., p. 414.
[3] Colmer: Am. Jour. Med. Sciences, 1843.
[4] Medin: Proceedings Tenth Int. Cong., vol. ii., div. iv.
[5] Briegleb: Inaug. Diss., Jena, 1890.

The epidemic reported by Caverly[1] in Vermont, around Rutland, in the summer of 1894, was very extensive and very severe. The epidemic included 132 cases, and 18 cases were fatal. The cerebral tracts were in several cases involved. An epidemic in Australia was reported by Alston in 1897, consisting of 14 cases.[2] An epidemic in Cherryfield, Me., was reported by Madison Taylor. There were 7 cases with 1 fatality.[3] W. Pasteur[4] reported in 1896 an epidemic occurring in 7 members of the same family. A very careful investigation of an epidemic occurring in North Adams, Mass., was made by Brackett.[5] Ten cases were seen and examined which in general were of a more severe type than ordinary cases. The initial fever was high, the distribution of paralysis was on the whole more extensive. The sphincters were at times involved, and prolonged hyperæsthesia was found in the severer cases. These features seem in general to characterize the epidemic cases as described by others. At North Adams all of the cases but one occurred along the banks of the two rivers flowing through the town; no other common etiological factor could be found.

PATHOLOGY.

The study of autopsies[6] in recent cases of infantile paralysis has resulted in the opinion among recent writers that the entire gray matter of the cord is the seat of interstitial inflammation and that the changes in the ganglion cells are secondary[7] (Sachs). Goldscheider's study would make it appear that the blood-vessels are first affected and that from these the neuroglia is attacked, and that the changes in the ganglion cells are degenerative and secondary in them as well as in the nerve fibres. The cases of Siemerling are confirmatory, and both sets lead to the view that the inflammation is interstitial and not parenchymatous.

The process may involve a few segments of the cord, or it may involve a greater part of the cord and extend to the medulla and pons. The larger ganglion cells of the anterior horns in the affected area disappear and the ones that remain are shrunken and the cell processes have disappeared. The entire gray matter of the affected side shrinks and even the white matter is smaller than that of the other side. The

[1] Journ. Am. Med. Assn., January 4th, 1896.

[2] Australian Med. Gaz., April 24th, 1897.

[3] Boston Med. and Surg. Journ., cxxix., 504.

[4] Trans. Clin. Soc. of London, 1896, p. 143.

[5] Trans. Am. Orth. Assn., vol. xi., p. 132.

[6] Goldscheider: Zeit. f. klin. Med., xxiii., 1893, p. 494.—Dauber: Zeit. f. Nervenheilkunde, vol. iv.—Siemerling: Arch. f. Psychiatrie, xxvi., 267 (with literature to 1894).

[7] Von Kahlden: Cent. f. Path., September 14th, 1894 (Charcot's view).

columns of Clarke disappear and the anterior nerve roots become smaller than those of the other side.

Atrophic changes soon take place in the paralyzed limb. Sometimes the atrophy affects the bones, which become shortened even to the extent of affecting the length of a limb by several inches. At the same time the affected limb grows comparatively smaller in circumference than that of the opposite side. This is frequently the result of

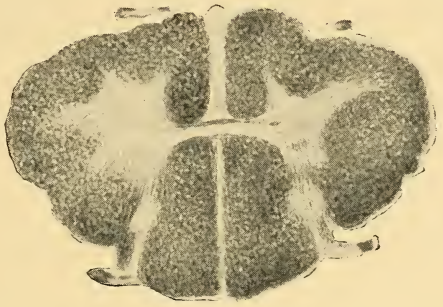


FIG. 368.—Anterior Poliomyelitis. Chronic stage; section through sixth cervical segment; diminution of anterior gray matter and of entire half of right side. (Sachs.)

retarded growth rather than of real wasting, but both factors at times enter into the change. In other instances, even in severe cases, the bones seem but little affected, while the atrophy of the muscles is very marked.

The epiphyses are stunted, and the ligaments become thin and loose, and dislocations and distortions of the joints are favored. It is in the muscles that the most notable changes are found. These waste rapidly and become flabby to the touch, and microscopic examination shows a loss of striation followed by a granular degeneration of the fibres until little is left beyond muscle corpuscles and fat granules contained in sarcolemma. This, of course, is clearly more than the atrophy of disuse.[1]

That poliomyelitis represents an acute inflammatory condition of the anterior gray matter of the spinal cord is conceded on all sides, but the question arises what the origin of such inflammation may be. The only satisfactory explanation at the present day is to suppose that the inflammation is the result of an acute infection which happens to be located in the spinal cord, just as other infectious diseases show a predilection for other sites in the body. The microbic origin has not yet been satisfactorily demonstrated, but all the clinical facts point toward this view, and the close dependence of the myelitic process upon the distribution of the blood-vessels lends further color to this theory.[2]

[1] Gowers: "Dis. of Nervous System," vol. i., 253.—Jacob v. Heine: *Loc. cit.*

[2] Sachs: "The Nervous Diseases of Children," New York, 1895.

SYMPTOMS.

In general the clinical history of the disease falls into three stages:

(*a*) The onset, to which stage belong the acute febrile symptoms and the development of paralysis.

(*b*) The stage of convalescence, which begins at the time of the full development of the paralysis, and is followed by a brief stationary period, and finally rapid and then slower improvement until a stationary period is reached.

(*c*) The stage of deformity, in which wasting of the affected limb is present and static, paralytic, and contraction deformities have supervened.

No arbitrary subdivision of the classes of symptoms will be made, because in reality the stages run into each other so gradually that it seems unjustifiable to divide them practically.

Infantile paralysis is oftenest ushered in by a mild or severe febrile attack, which presents no definite characteristics to distinguish it from any ordinary attack of cold or indigestion. The elevation of temperature is not excessive, commonly from 100° to 102° F., sometimes even 104°. With this fever are apt to be associated vomiting, convulsions, giddiness, or other cerebral disturbance, sometimes even delirium. Older children complain of pain in the back and limbs. There is, as a rule, no warning of the attack, although Seeligmüller has noted at times a disinclination to walk or stand as much as usual for some days preceding—a fact quite in accordance with Lange's theory that overexertion of the muscles has much to do with the production of the disease. Convulsions may be present, and when they occur they are usually followed by a period of unconsciousness. The feverish attack at the onset may, however, be very severe, at times lasting two or three days (or even weeks) before the paralysis appears. More commonly, however, it is very slight and scarcely noticed. In certain rare cases, two or even three attacks of fever are noted, each followed by an increase in the paralysis. Pain of a rheumatic character in the back and limbs is a common initial symptom. In certain cases all feverish and other symptoms are absent at the onset, and the child is suddenly discovered to be paralyzed in one or more limbs. Such paralysis comes on oftenest in the night, but it has been observed to come on quietly in the daytime, while the child was at play. In these cases there may be no succeeding illness, and the paralysis is the only symptom throughout.

Diarrhœa, vomiting, general hyperæsthesia, and much nervous irritability are other symptoms which often accompany the onset of the paralysis. During the first few days there may be paralysis of the bladder with retention or incontinence of urine, but it disappears after a

few days or weeks. Pain is a symptom but little noted in infantile paralysis, but it is not uncommon, nor does it indicate of itself the presence of any additional pathological process.

The paralysis itself very quickly becomes manifest and reaches its maximum within a few hours of the attack, or within a day or two, except in rare cases. Having reached its maximum and remained stationary for a short time, improvement almost invariably begins. In rare cases improvement begins immediately after the attack and proceeds to complete recovery. These are the cases which are spoken of as "temporary spinal paralysis." The more common course is for the paralysis to remain nearly stationary for a time varying from two to six weeks, and then to improve, at first rapidly and then more slowly, for three or four months. After six months have passed, further spontaneous improvement is unusual.

Vascular changes become very marked. The temperature of the limb is much lower than that of the other. The limb is generally bluish, with a superficial stagnation of the blood, on account of an atrophy of the blood-vessels and consequent diminution of their calibre, and when the blood is pressed out of the surface capillaries by the finger it returns slowly. On account of this vascular sluggishness ulcers may form, which are slow to heal and very painful. The limb even very early loses its normal appearance, and the flaccid undeveloped look of the foot or hand is most noticeable.

Atrophy of the affected muscles begins to be perceptible a few weeks after the onset of the paralysis, while the loss of striation in the muscular fibres can be detected with the microscope within two or three days of the attack.[1] The muscles may be tender to the touch during the time that they are wasting so fast, especially in adults and older children. Muscles seriously affected are toneless and flaccid from the first, and in the late stages of wasting scarcely any volume of muscles seems left when the limb is grasped with the hand.

The paralysis is a purely motor one, and although tingling and formication may be present, sensation is very rarely affected. The reflexes are abolished in the affected limb if the implication of the extensor muscles of the thigh be enough to do away with the knee jerk of the affected side.

Sometimes after an attack the paralysis may seem to be general, but the probabilities are that after improving in general, the loss of power will eventually be localized in one limb, and that if one limb originally is paralyzed the likelihood is very great that a certain amount of power will be regained, leaving only certain groups of muscles permanently paralyzed.

[1] H. W. Berg: Wood's "Ref. Handbook," vol. v., p. 504.

Distribution.—The paralysis in its distribution is monoplegic in about half the cases, as the tables taken from the cases of Duchenne, Seeligmüller, Sinkler, and Starr will show:

Both legs,	170
One leg,	246
Both arms,	6
One arm,	47
All extremities,	47
Arm and leg, same side,	33
" " " opposite sides,	8
Trunk,	26
Three extremities,	12
	595

The great preponderance of paralysis of the lower extremities is to be noted, and the liability to paralysis increases even from the thigh to the foot, and when improvement begins in a case in which both an upper and a lower extremity are paralyzed, the improvement begins first in the arm. Commonly certain groups of muscles are attacked, and when adjacent muscles are affected they seem to be selected at random oftener than by functional or anatomical association. In the leg, the extensors and the peronei are the muscles oftenest affected. The glutei are never affected alone, but they commonly share in any extensive paralysis of the leg. In the arm the deltoid suffers oftener than any other arm muscle, either alone or in association with other muscles. The "upper-arm type" of paralysis, which Erb has described, consists of the simultaneous affection of the deltoid, supra- and infraspinatus, the biceps, and the supinators. There is also a "forearm type" described by Remak,[1] in which, as in lead paralysis, the extensor muscles of the hand are paralyzed while the supinator longus is spared. The serratus magnus is sometimes affected as well as the trapezius and pectoralis major. The neck muscles are very seldom affected and the muscles supplied by the cranial nerves only rarely.

The muscles of the back may be paralyzed and the patient be unable to sit erect, or lateral curvature may result—a state of affairs often made worse by allowing the patient to sit erect while the muscles are still weak. The diaphragm is occasionally paralyzed. In those rare cases of paralysis of the abdominal muscles, the patient leans back to a very marked degree, missing the restraining action of the abdominal muscles. There are, finally, cases of universal paralysis in which death soon takes place from interference with respiration.

The sequelæ of the disease are few.

[1] Remak: Arch. f. Psych., Band ix., 1878–79, p. 510.

Deformities.—The deformities which come on after infantile paralysis are late events in the history of the disease and rarely develop until at least some months after the attack. They are, as a rule, progressive in their character and the end results are often such extreme distortions that the affected limb is useless. The deformities fall into two chief classes: (1) deformities due to trophic changes, such as bone shortening, etc.; (2) deformities due to muscular paralysis.

(1) The first class is comparatively unimportant; shortening of the paralyzed arm or leg may take place with atrophy of the bone in every direction, so that a liability to fracture is of course a necessary consequence. Shortening of the arm is comparatively unimportant in itself, but shortening of the leg is likely to induce lateral curvature of the spine from the necessarily tilted position of the pelvis [1] due to the unequal length of the legs.

(2) The deformities of the second class, which are the result of muscular paralysis, are manifold and form the great bulk of the cases of deformity in anterior poliomyelitis. As a rule they do not appear earlier than two or three months after the onset and more commonly not for many months.

For clinical consideration they fall into two groups: deformities caused by contraction, and deformities due to laxity of the muscles and ligaments. Volkmann, on the ground of Hüter's investigations, explained nearly all the deformities on mechanical grounds, urging that the deformities were developed partly by reason of the weight of the limbs concerned and the position which they assumed when at rest, and partly because of the muscular insufficiency of the affected limbs which allowed the articular surfaces to be subjected to an excessive pressure when brought into use, which had the effect of gradually pressing them into abnormal position. The earlier idea had been, however, that they were brought about by the unopposed action of the muscles which were not affected. Probably both factors are active in the causation of deformity.

A word should be said in regard to the reason of the more severe affection of the anterior leg and thigh muscles than of the posterior muscles in nearly all cases. The theory has been advanced that, after a paralysis of the leg, the limb lies flaccid and nearly powerless, the toes drop, and, if the sitting posture is assumed, the knees flex and the legs hang heavily down. As a result of this, the anterior muscles are always pulled upon and slightly stretched, while the posterior ones are lax. If all the muscles are equally affected, this very factor may be enough to make a great difference in the ultimate usefulness of the two groups. Stretched muscles are notoriously at a disadvantage, so far as

[1] Bradford: "Etiology of Lateral Curvature," Boston Med. and Surg. Jour., 1886, cxiv.

recovery goes, in any diseased condition, and muscles at rest are much more favorably situated. So that this very point may determine in a measure the relative amount of recovery in the two groups.

Moreover, muscular contraction and consequent deformity occur only in cases in which a muscle has been allowed to remain for a long time in a shortened or stretched condition. For this reason it is highly important to support and restrain the affected limb in a normal position (the foot at a right angle to the leg, etc.).

The common deformities from infantile paralysis which come to the orthopedic surgeon for treatment are those of the lower extremity. Considered in detail, it is best to begin with deformities at the hip-joint and then to pass on to the consideration of knee-joint deformities and distortions of the foot.

FIG. 369.—Kyphosis in Advanced Paralysis of the Back Muscles.

FIG. 370.—Infantile Paralysis. Contractures of right leg. (Weigel.)

Deformities of the Leg.—Paralysis may be complete and a flail-like leg be the result, with wasted muscles and loose, distorted joints, incapable of motion or bearing weight. Such a limb is spoken of as "jambe de Polichinelle."

But more commonly the paralysis is partial rather than complete.

The muscles of the thigh commonly affected are the internal and anterior groups. This constitutes a serious combination and renders walking difficult; not only is the leg abducted with a tendency to eversion, but the extensor thigh muscles cannot hold the knee rigid as is necessary in walking, the leg giving way whenever weight is put upon it. The glutei are generally implicated in this paralysis, and the contraction

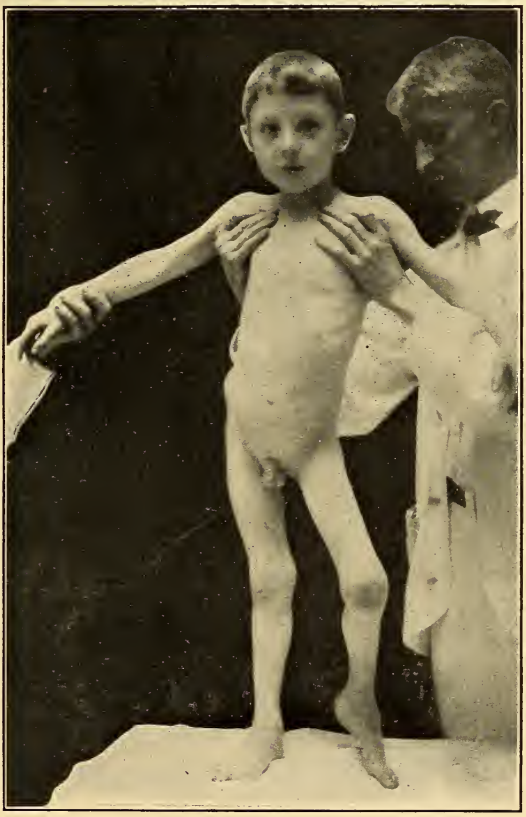


FIG. 371.—Paralysis of the Left Leg, with Talipes Equinus and Involvement of the Internal Rotators and Abductors of the Leg, Resulting in a Position of Abduction and Eversion.

which is likely to result from this paralysis is flexion of the thigh alone or with abduction of the leg, a condition always associated with flexion of the knee and talipes equino-varus.

Flexion deformity at the hip produces in time a most marked lordosis in the back. When the patient stands with the leg dangling, the weight of it drags upon the pelvis and rotates it on a transverse axis, a compensation which makes it possible for the leg to hang as nearly as possible perpendicularly. This deformity is marked and troublesome.

At the knee, contraction in the flexed position (with often a tendency to subluxation of the tibia backward) is found, and in the more severe cases decided knock-knee. At other times when laxity rather than contraction predominates, hyperextension of the knee is observed and sometimes lateral mobility also exists. In severe cases of this type

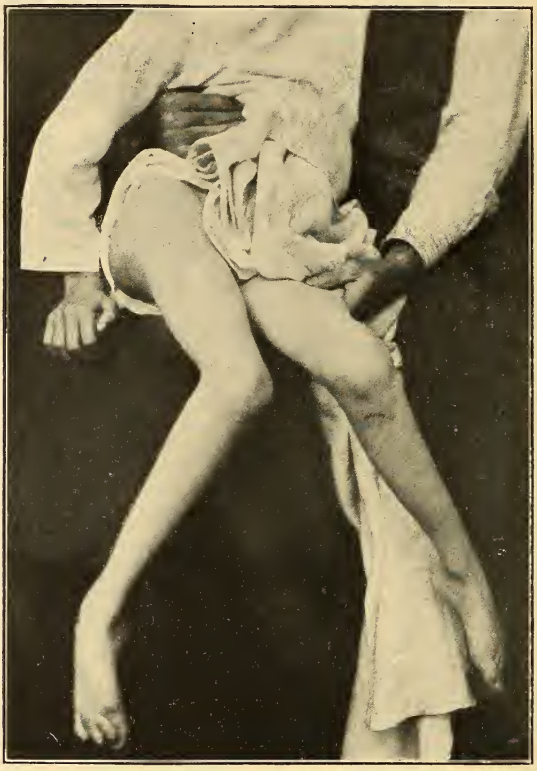


FIG. 372.—Severe Double Paralysis with Marked Knock-knee and Distortion of Feet. This patient was unable to walk.

in which the deformity has been rectified by mechanical or operative means, the tibia lies in a plane decidedly posterior to that of the femur. The same may be said of the knock-knee which results from the greater prominence of the internal condyle of the femur. The flexion may have been overcome, but still a decided degree of knock-knee may remain in the corrected leg.

Hyperextension of the knee may also increase to a very marked degree and is commonly associated with talipes valgus. This hyperextension results in cases in which the anterior muscles are weak and fail to hold the knee extended when walking is attempted. In these cases the patient throws the weight of the body upon the fully extended knee

and the strain falls upon the ligaments rather than on the muscles. The posterior ligaments yield in time to this repeated weight and the patient obtains for a time a better bearing. The same deformity is favored by a tendency which these patients have to lean with the hand upon the knee when rising from a chair.

There is a tendency to outward rotation of the tibia upon the femur in cases of long-standing paralysis of the leg. In this case the eversion of the foot in walking is a troublesome complication.

Inasmuch as paralyses of the anterior tibial muscles and the peronei are the most frequent,[1] the deformities that one sees oftenest are talipes

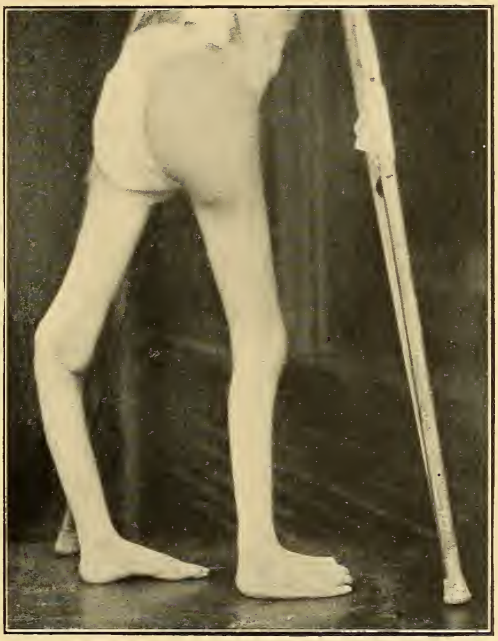


FIG. 373.—Hyperextension of the Left Knee due to Paralysis of the Limb. Varus deformity of the right foot.

equino-varus, or, if the peronei are intact, talipes equinus. Pure talipes varus from this cause is not common.

It will be seen that hyperextension of the knee is favored in cases in which talipes equinus exists, as by that means alone the foot can be placed flat on the ground.

Talipes calcaneo-valgus and pure flat-foot are favored by lax ligaments, and the latter may be a progressive deformity, which increases until a stage is reached in which the inner malleolus almost touches the ground and the foot can be flexed until the dorsum touches the skin

[1] Ross: "Dis. of Nerv. Syst.," William Wood & Co., 1878, p. 942.

over the tibia. The bearing of body-weight on a foot, the ligaments and muscles of which are weak, tends to produce flat-foot.

Pure talipes calcaneus seems to be the result of the paralysis of the posterior calf muscles combined with the action of gravity and superincumbent weight. What is known as pes cavus is more common than pure talipes calcaneus.

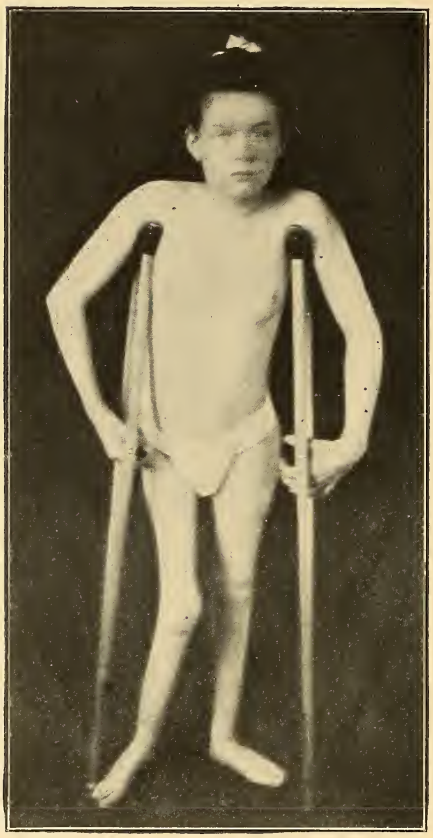


FIG. 374.—Paralysis of Both Legs, Severest in Right. Knock-knee and flail-like legs. This patient was unable to walk without crutches.

The order of frequency of the different forms of deformity from anterior poliomyelitis is as follows: (1) talipes equino-varus; (2) calcaneo-valgus; (3) equinus; (4) calcaneus or pes cavus.

Deformities of the arms are not common as the result of infantile paralysis. The least infrequent of these results from the paralysis of the deltoid. In addition to the inability to raise the arm from the side, there are present a flattening of the shoulder and a prominence of the acromion process, and the shoulder presents an angular rather than a rounded outline. The ligaments are loosened, and the arm hangs loosely, so that in some cases a wide gap may be observed between the acromion and the humerus.

Any distortion of the arm and hand further than the flaccid condition resulting from the paralysis is quite rare. If contraction does occur, it follows the type to be seen in adult hemiplegia: flexion of the elbow, hand, and fingers. The commonest paralysis of the hand is one affecting the adductor muscles of the thumb, as a result of which the thumb is drawn back to a level with the other fingers and the power to oppose it to the other fingers in grasping is thus lost.

Infantile paralysis of the sterno-mastoid muscle is recognized as an occasional cause of wry-neck. Paralysis of the intercostal muscles rarely causes deformity, but Gowers saw a case in which a permanent depression in one side of the thorax resulted from such a paralysis.

Paralysis of the erector spinæ muscles results in a permanent arching of the spine and inability to sit erect. Paralysis of the abdominal muscles causes lordosis.

Lateral curvature of the spine results from infantile paralysis in one of three ways:

(1) From the inequality in the length of the legs (due to paralysis of one leg), causing tilting of the pelvis. (2) From the unilateral paralysis of the muscles directly controlling the vertebral column, which might be either a paralysis of the intrinsic spinal muscles or of the erector spinæ group on one side. (3) From faulty spinal attitudes assumed in consequence of some paralysis elsewhere, as in paralysis of one arm, or of the serratus magnus, or even of the sterno-mastoid. These cases have been more particularly considered under the head of lateral curvature.

Dislocations from Infantile Paralysis.—Dislocation, complete or partial, belongs to the more uncommon of the complications of infantile paralysis and characterizes severe cases.

Dislocation of the hip is the one most commonly met and it takes place either spontaneously or in consequence of weight being borne

FIG. 375.—Paralysis of the Back Muscles, Causing Saddle-back Deformity.

upon a limb which is improperly supported by its ligaments. It occurs chiefly in cases in which the paralysis is severe and of long standing, and it may disable the leg on account of the laxity with which the femur articulates with the pelvis. A shortening of one or two inches may be present, as the dislocation is generally on to the dorsum of the ilium;

but sometimes it takes the form of a laxity of the joint in all directions, so that the head may be thrown into any position by manipulation of the shaft. Most dislocations of the hip are inconvenient chiefly because of the shortening and insecurity which follow the displacement of the head of the bone. But the head of the bone in a year or two becomes often quite firmly fixed in its new position, and such legs are sometimes nearly as serviceable as they were before. Dislocation may, however, occur before any weight is borne upon the affected limb, by the spontaneous action of the muscles, as in a patient eighteen months old, in the experience of one of the writers, in which dislocation of one hip took place at the age of three months. In this case the dislocation was reduced under an anæsthetic, and by the application of a plaster-of-Paris bandage the head of the femur was permanently retained in the acetabulum. These dislocations are rarely attended by much pain and are often overlooked by the parents.

FIG. 376.—Paralysis of the Left Arm Muscles, Deltoid and Serratus Magnus.

FIG. 377.—Moderate Degree of Talipes Valgus, Right Foot.

Laxity of the knee-joint, so that the joint surfaces slip by each other in the motions of the joint, is a less common affection, but is sometimes seen. In these cases the joint is subluxated at each step.

The subluxation of the tibia in severe cases of knee flexion and the dislocation of the shoulder after paralysis of the deltoid muscle have been already mentioned.

DIAGNOSIS.

In typical cases the diagnosis of infantile paralysis is not difficult. But in other than typical cases the recognition of the disease may be extremely difficult, and it is never easy to establish a positive diagnosis in the initial stage. At that time the occurrence of localized pain may be a misleading symptom, and sensitiveness of the affected limbs may suggest rheumatism. The occurrence of convulsions and unconsciousness may divert the attention to the brain, and all sorts of side issues may be suggested by the manifold symptoms of the onset of the disease. The affection is often wrongly classed as cerebrospinal meningitis at the earliest stage, as the head is sometimes drawn backward in severe cases.

The diagnostic points upon which the practitioner must rely are the sudden onset, a motor paralysis, rapid muscular wasting, the distribu-

FIG. 378.—Talipes Varus, Right Foot.

tion of the paralysis (mostly monoplegic and very rarely hemiplegic), and the loss of the tendon reflex. Diagnosis by the determination of the electrical reaction of the muscles requires especial training and skill, although it is distinctive and the most reliable test at our command.

Electrical Condition of the Muscles.—The electrical reactions in infantile paralysis are clearly marked and characteristic when they can

be obtained. Faradic irritability of the affected muscles and nerves begins to diminish within a day or two of the onset of the paralysis, and in muscles severely affected the electric irritability disappears entirely; in the muscles less seriously involved it is merely diminished. This constitutes a valuable symptom in prognosis, as in muscles which are completely paralyzed *faradic irritability is permanently lost by the second week.* But even in later years it may be possible to find in such muscles a trace of irritability to the faradic current by thrusting a hypodermic needle into the muscular substance and transmitting the cur-

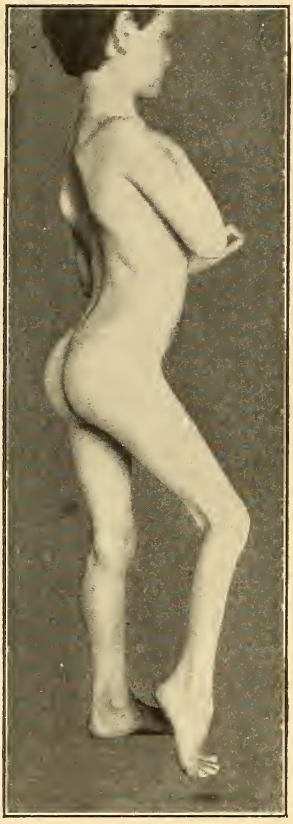


FIG. 379.—Flexion Deformity of the Hip, Knee, and Ankle, due to Contractions.

FIG. 380.—Dislocation of Hip, the Result of Infantile Paralysis. In this position the head of the femur (left) is in place, but with abduction it slips out again.

rent through that. But the change in reaction to the galvanic current is even more important. Normally when this current is passed through nerve and muscle, a quick, sharp muscular contraction takes place at the opening and closing of the current, and the muscular contraction

should be greater at the closing of the negative pole than when the positive pole is closed. The cathodal closing contraction should be normally greater than the anodal closing contraction. When nerves and muscles affected by anterior poliomyelitis are examined, not only a

FIG. 381.—Same Case as Shown in Fig. 380, with Hip Dislocated.

FIG. 382.—Old Paralysis of Left Leg with Slight Knock-knee and Talipes Varus.

slow wave-like response to electricity instead of a sharp quick jerk is found, but the electrical formula is reversed and *the closure of the positive pole gives the greater contraction.* In general a much stronger galvanic current is needed to produce a contraction in these paralyzed muscles than in normal ones. These qualitative and quantitative changes in reaction to the galvanic current constitute what is known as the "reaction of degeneration," and this affords the most definite ground for the diagnosis of infantile paralysis. But such an examination to be of any value requires practice and special skill in the use of electricity. In young children the examination often yields no results even to a specialist in nervous diseases on account of the child's constant activity, and although it is the most definite means of diagnosis that we possess in obscure cases, its use is attended with many difficulties.

The only affection which may not be distinguished by electrical examination from anterior poliomyelitis is peripheral paralysis caused by interruption in the course of some nerve.

DIFFERENTIAL DIAGNOSIS.

The leading points which are to be depended upon in the differential diagnosis are these: Infantile paralysis is purely a motor affection and sensation is never permanently impaired. The reflexes are generally diminished or lost. Wasting is rapid and extreme and the leg is cold and blue in severe cases. The "reaction of degeneration" is present in electrical examination.

Cerebral paralysis generally begins with a sudden onset, and often convulsions are present and the child is found to have lost the use of one side of the body. It differs from infantile paralysis in these points: its distribution is hemiplegic and facial paralysis is common, the tendon reflexes are increased from first to last, faradic excitability is not lost, and the galvanic formula is normal; later the intelligence is generally affected and atrophy is neither so marked nor so rapid as in infantile spinal paralysis, but similar contractions of the joints of the affected limb come on. These contractions are, however, often spastic in character. Allusion must be made to the importance of electricity in making a differential diagnosis, which is often attended with much difficulty. A hemiplegic distribution of infantile spinal paralysis is rare, but cases have been reported in which the facial nerve was involved.[1]

TABLE OF THE DIFFERENTIAL DIAGNOSIS OF INFANTILE PARALYSIS AND CEREBRAL PARALYSIS.

	Infantile Spinal Paralysis.	Cerebral Paralysis (Hemiplegia).
Age.	Sharply limited to children in first dentition.	Not sharply limited to young children.
Onset.	Sudden, but severe convulsions not often present.	Sudden, and severe convulsions generally present.
Distribution of paralysis.	Oftenest monoplegia or paraplegia; rarely involves facial nerve.	Hemiplegia; generally involving facial muscles on one side.
Reflexes.	Lost generally.	Increased.
Electrical reaction.	Faradism, diminished or lost.	Faradism, normal.
	Galvanism, formula reversed (reaction of degeneration).	Galvanism, normal.
Mental impairment.	Absent.	Likely to come on.
	Spastic condition absent.	Spastic condition of one or both legs often follows.

Progressive muscular atrophy in childhood is a very rare affection, but it has been observed, sometimes beginning in the legs. Its onset

[1] Henoch: *Loc. cit.*, p. 203.—Barlow: *Loc. cit.*, p. 76.—Seeligmüller.

is gradual, and the faradic excitability remains so long as there is any muscular substance left and the galvanic formula remains normal. The reflexes are not lost until all muscular substance has gone.

Acute transverse myelitis of the dorsal region causes paralysis of the legs when it occurs, but unless the lumbar enlargement is involved there is no loss of electrical irritability. Reflex action after a day or two is much increased and ankle clonus can be obtained. There is generally paralysis of sensation, and bed-sores develop with much rapidity, while any wasting is very gradual. There is no change in the electrical formula.

A paralysis much like that in anterior poliomyelitis has been described by Bullard following *cerebrospinal meningitis*.[1] In such cases pain and tenderness of muscles persist longer than in infantile paralysis. There is a tendency to spastic contraction in the early stages, which becomes less later. The knee-jerks on the whole are less affected than in infantile paralysis; they may, however, be absent entirely.

Diphtheritic paralysis may offer serious difficulty in diagnosis, because anterior poliomyelitis may occur in the course of a diphtheritic attack as in any other infectious disease. The paralysis of diphtheria affects oftenest the muscles of the palate and fauces, the electrical reactions remain normal, and severe atrophy is not present.

Pseudo-hypertrophic paralysis in its early stages is not likely to be confused with infantile paralysis, for it is generally characterized by much increase in the size of the muscles, which is extensively distributed and comes on very gradually and is not accompanied by any marked electrical changes. Late in the affection marked muscular atrophy occurs, but it is generalized and the history would clearly differentiate the condition from anterior poliomyelitis.

Paralysis may result from *lesions of a peripheral nerve*, as in instrumental delivery at childbirth, from tight bandaging, etc. But its distribution is limited to a single nerve or group of nerves, and it is characterized by a concomitant affection of sensibility. The electrical reaction would be the same as in infantile paralysis.

The so-called *rhachitic paralysis* might offer some difficulty of diagnosis. But it occurs in the acute stage of rickets and is not a paralysis so much as a disinclination to use weak and tender limbs. It is accompanied by general tenderness and to a certain extent by the diagnostic signs of rickets, the reflexes are normal, and its onset is more gradual. It is, however, so early a complication of rickets that its recognition may offer difficulty.

Infantile paralysis of one leg may produce a limp in gait which suggests *congenital dislocation of the hip*, but only on a superficial exami-

[1] Boston Med. and Surg. Journ., vol. i., p. 159, 1899.

nation. In congenital dislocation the trochanter would be above Nélaton's line, atrophy would be very slight, and the electrical reaction normal.

With *hip disease*, infantile paralysis is at times confounded in practice. The onset of the paralysis may be accompanied by joint pain and tenderness, and, on the other hand, hip disease is accompanied by muscular atrophy and a modification of faradic irritability of the muscles. But the distinguishing feature of hip disease is muscular fixation, and that is not present in infantile paralysis, in which muscular laxity is the prevailing condition. The onset of hip disease, although generally gradual, may at times be apparently sudden.

PROGNOSIS.

So far as danger to life is concerned, the outlook in infantile paralysis is very favorable, for few patients die in the acute attack. When death does occur it is generally at the end of a week or ten days. Continued cerebral symptoms, however, are of grave significance. In cases in which the deformity is only of moderate extent, it is not probable that life will be shortened by it.

It is not likely that the paralysis will increase if it has been stationary for twenty-four hours. Second attacks are very rare, and when they do occur, they come on within a day or two of the original attack and are made evident by an increase of the existing paralysis.

The tendency of the paralysis, as we have seen, is toward improvement and partial recovery. The law of Duchenne suggests a more exact prognosis in the fact that all the paralyzed muscles in which the faradic irritability is only more or less diminished, but not completely lost, during the course of the second week, do not remain permanently paralyzed, the restoration being more prompt and complete the less the faradic irritability has been diminished. In general, when the faradic irritability is lost at once, paralysis will be severe and to a certain extent permanent. When the irritability is lost later, the paralyzed muscles will improve slowly and nearly recover. When faradic irritability is not lost at all, recovery will take place in a few weeks or months. Without the use of electricity one has to wait much longer before giving any more definite prognosis than a general promise of improvement.

When untreated, a case of infantile paralysis will almost invariably improve for one or two months at a rapid rate, then more slowly for two or three months more, and then after a stationary period, contractions, looseness of the joints, and malpositions are likely to begin, which may increase indefinitely. Under treatment the prognosis is much more favorable and the limit of possible improvement extended by many years.

It should be remembered that even in mild cases of infantile paralysis bone shortening may follow. Certain severe cases escape with but little, while a mild case of talipes valgus may show, with the wasting of the leg, a shortening of one or two inches in the limb of the affected side, or, in exceptionally severe cases, shortening of several inches.

A large measure of success in the orthopedic treatment of infantile paralysis in the stage of deformity can be expected in a large percentage of cases, exclusive of the hopeless class where a large portion of the body is permanently paralyzed. If correction of the deformity, mechanical treatment, massage, dry heat, and all practicable use of the limb aided by apparatus be begun at as early a stage as possible, development of the strength of many muscles not completely paralyzed, but weakened from disuse after the original onset of the disease, can be expected, materially benefiting the patient. This can be supplemented if necessary by tendon transference or arthrodesis. By thorough surgical care what would be a condition of hopeless affliction can be converted into a slight or endurable disability.

TREATMENT.

The treatment of infantile paralysis varies according to the stage at which treatment is to be undertaken, and is either stimulative to check the paralysis, or corrective to prevent or improve deformity. For the latter purpose it is either mechanical or operative.

The Stage of Onset.—If the fact that paralysis is present is established during the febrile attack, which is usually the first symptom of the disease, vigorous treatment should be at once begun, to limit, if possible, the destructive process in the cord. Cathartics should be given at once, the patient should lie on the side or the belly, to prevent stasis of the blood in the spinal cord, and counter-irritants or cups should be applied over the spine. Ergot should be administered in doses of ten drops of the fluid extract, three times a day, for infants of six months, and half a drachm for children of one or two years. Bromide of potassium and of sodium and strychnia are recommended. The general condition of the child should in every way be kept as good as possible. Antipyretics may be indicated.

The Stage of Paralysis.—But few cases are seen by the surgeon until the stage of paralysis is present, when treatment by medicine is manifestly of little avail. The question that then presents itself is in regard to the treatment of the paralysis, in order that the ultimate amount of muscular power may be as great as possible. It must be remembered that the tendency of the paralysis is at first very strong toward spontaneous improvement. It is therefore manifest that in the first few weeks treatment should be directed toward producing condi-

tions which shall be as favorable as possible for that improvement to attain its maximum.

The object of treatment in this stage should therefore be, first, to support the affected limb in a normal position, and most carefully guard against the stretching of joints and ligaments and muscles; and, secondly, by the use of electricity, massage, and systematic exercise to keep the nutrition of the affected muscles in the best possible condition. In this way only, by beginning the treatment at the first, can the best possible ultimate result be obtained.

It has been seen that what may be called protective treatment should be begun at once, and from the first the diseased limb should be placed and retained in a normal position, so that the affected muscles and joints may be supported and kept at rest and relaxed. In this way the enfeebled muscles are placed under the best possible conditions for their recovery. To allow attention to be diverted from these very important measures to pursue a medical treatment whose utility is doubtful, is manifestly irrational. In paralysis of the legs the feet should be supported from the first at a right angle, in their normal position, by some simple splint or similar appliance, and the weight of the bed clothes should be kept off of the toes.

The appliances needed to maintain in a proper position the limbs of a patient with paralysis will vary according to the parts affected and will demand some ingenuity on the part of the surgeon. In severe and extensive cases light bed frames may be very useful to allow the patient to be carried about, while retaining the limbs in a proper position. So far as possible in such cases bandages should be avoided, and straps should be used instead, as the surface circulation is feeble and likely to be impeded by bandages.

When the arm is paralyzed, a sling should be worn to prevent dragging of the arm upon the shoulder-joint ligaments and the weakened deltoid muscle, or, if the deltoid is chiefly affected, the arm may be supported on a frame holding it at right angles to the trunk.

Electricity is a most useful therapeutic measure in the early stages of the paralysis. Treatment should be begun as early as the spinal irritation seems to have disappeared, probably about the end of the first week, and continued indefinitely, but not to the exclusion of proper mechanical treatment. The galvanic current is used; a very gentle current is passed through the affected muscles and nerves for a few minutes each day, and muscles which contract only feebly to faradism should be daily stimulated by the application of the faradic current. Muscles which will not contract to faradism can sometimes be much improved by applications of the interrupted galvanic current. The chief use of electricity, it is to be remembered, is to stimulate to contraction the paralyzed muscles, thereby affording a sort of gymnastics.

Probably electrical treatment receives much credit in the treatment of this disease, which is not improperly due to it, for it is employed at a time when marked improvement is almost certain, and very much the same results can be obtained by methods about to be considered. One sees cases in which it has ceased to benefit the child and has been persisted in to the exclusion of more rational treatment for that especial case. But even in the late stages of the disease, when wasting and deformity have come on, the use of electricity may at times lead to an improvement of nutrition.

Dry warmth and rubbing are measures which seem of equal, if not of greater, value in the stage of simple paralysis. Heat is easily applied by having the child sit in front of a fire or stove with the leg

FIG. 383.—Clawed Toes and Pes Cavus following Infantile Paralysis.

thrust through a hole in a sheet of pasteboard. This serves as a screen to the rest of the body, while the affected member is allowed to become thoroughly warmed once or twice a day either in this way or by a hot-air oven. During the day, especially in cold weather, the paralyzed limb should be protected by two thick stockings and a warm boot. Any treatment which stimulates the circulation of the paralyzed limb aids in its recovery by improving the nutrition of the muscles, and dry heat very effectually accomplishes this end. A paralyzed leg should be thoroughly heated for an hour before it is rubbed at night.

Massage is another most important element of treatment in this as in any stage of infantile paralysis after the initial irritation has quieted down. Skilled massage, when it can be obtained, is of course better than friction at the hands of the parents, but the latter is a simple and efficient treatment, which lies within the reach of most people.

In the place of the usual manual massage, mechanical massage of the limbs has been employed by means of carefully constructed appliances. This, however, will be within the reach of but few.

Active muscular exercise of the paralyzed limb is a most desirable tonic to the affected muscles, however it is obtained, provided the muscles be not overtaxed. With the assistance of the parent's hand, a foot which naturally drops forward from paralysis of the anterior leg muscles can be flexed, and with each repetition of the exercise the muscle may be found able to accomplish more. It is impossible to lay down any series of exercises. In each case the problem must be met differently. The aim should be so to assist the affected muscles that if they have any power left they may be enabled to use it daily for their own advantage. And with this in view, assistance should be rendered by supporting and aiding the affected limb in its movements in the way most likely to call into use these paralyzed muscles. Such exercise forms a most useful adjunct to the massage. It should be repeated each night just before or just after the massage.

H. L. Taylor, in an excellent paper on the hygiene of reflex action, says: "In the neuromuscular degenerations following acute anterior poliomyelitis, it is especially important to restore to the paretic extremities, so far as possible, the stimuli of locomotion and other normal associated movements without the inhibition of insecure footing and strained tissues—and it is for the specific purpose of restoring to the damaged cord and muscles the cutaneous, muscular, and articular stimuli of locomotion that apparatus is constructed."

Mechanical Treatment.

The mechanical treatment of infantile paralysis is twofold in its object. The first and simplest use of apparatus is to support and protect the paralyzed limb in such a way that the muscles shall work to the best advantage and that the joints may be supported and controlled. By doing this the occurrence of contraction deformities is prevented and the nutrition of the limb is kept in the best possible condition by enabling the limb to be used in a comparatively normal way.

The second function of mechanical treatment in infantile paralysis is to overcome by means of suitable appliances deformities which have already occurred and to prevent their recurrence; it may often be necessary to attempt both objects with one apparatus.

The Indications for Mechanical Treatment.—Whenever a paralyzed limb is unable to bear the weight of the body which falls upon it in locomotion, some mechanical help is manifestly advisable. This is not only needed when the paralysis is complete, but also when, owing to incomplete muscular strength, more strain is borne on the articular ligaments than is normal. Moreover, when the bearing of the body-weight or the act of walking throws the foot or the leg into any abnormal position, the use of some appliance is indicated. It is difficult to describe

the various appliances needed in the treatment of infantile paralysis, and much must be left to the ingenuity of the surgeon in each case.

Paralysis of the Leg.—When the muscles of the leg are paralyzed, those which help to control the ankle-joint in standing and walking are rendered inefficient and the ligaments may become relaxed, so that in the standing position the ankle of the affected side cannot sustain the body-weight as it should, and the foot is apt to roll in or out, causing an inversion or eversion of the foot amounting to a degree of talipes varus or valgus.

In any apparatus which is to sustain the foot in its weight-bearing function, accuracy of support is indispensable, and a simple leather boot, however stout it may be, soon yields and the foot slips away from the rest of the apparatus, and the efficiency of the brace is impaired; a rigid sole is, therefore, essential for any apparatus which is to control the ankle properly, and this can easily be accomplished by having a thin steel plate inserted between the layers of the sole of the boot.

When no contraction or deformity exists at the ankle, but there is simply a tendency of the front of the foot to drop on account of the affection of the anterior muscles of the leg, locomotion can be made much more easy by preventing this. A common appliance for this latter deformity is an ordinary shoe fitted with lateral steel uprights and a posterior steel calf band (Chapter XXI., **28**). There is a right-angle stop catch at the ankle which keeps the foot from dropping.

The same end can be better accomplished by the application of a walking appliance, described under club-foot as an equino-varus shoe, which should be provided with a right-angle stop at the ankle which will not allow the ankle to be extended to more than a right angle (Chapter XXI., **27**). When in bearing weight upon the leg the ankle assumes a varus position, a varus shoe will correct the tendency to deformity (Chapter XXI., **30**).

If the foot rolls out and is everted into a valgus condition when the body weight is borne upon the leg, an outside shoe is to be applied, in construction like the varus shoe, but which should have a broad leather strap which should pass around the inner malleolus and support it (Chapter XXI., **31**). This apparatus is a difficult one to render quite comfortable to the patient, as much weight must necessarily come upon the strap which supports the inner malleolus. As flat-foot is almost always present in these cases, it is well to arch the steel sole plate of this apparatus so that it serves as a valgus plate as well as a supporting appliance.

If calcaneus is present the apparatus spoken of for equinus is used, with the stop catch reversed to prevent dorsal instead of plantar flexion (Chapter XXI., **29**).

Pes cavus may be treated by inserting a steel sole in the sole of the

boot and passing a strap from the sole over the dorsum of the foot. This treatment is made much more efficient if combined with preliminary division of the plantar fascia. Mechanical treatment alone is likely to be unsatisfactory.

Talipes calcaneus may be treated by fixing the foot for months in a position of talipes equinus by means of a plaster bandage. At the end of this time a shortening of the muscles at the back of the leg will be found.[1]

It is manifest that the simpler and lighter these appliances are and the less unsightly, the more serviceable they will prove. For this reason they should be carefully fitted and the uprights made to follow the outline of the leg. In very slight cases, in which there is only a slight eversion of the foot with a small degree of valgus, a common valgus plate (Chapter XXI., **32**), such as would be applied for flat-foot, will often answer every purpose in correcting the deformity, and it should be applied as in simple flat-foot.

In severe cases of paralysis of the muscles of the legs and foot, the thigh muscles may be involved. The same appliance will often have to support the knee and thigh as well as to correct deformity at the ankle. But this involves merely an extension of the apparatus up the leg.

Paralysis of the Thigh Muscles.—When the muscles of the thigh are involved in the paralysis, the limb becomes unable to sustain the weight thrown upon it and the knee flexes and the limb drops forward when weight is borne upon it. The knee-joint does not bend to one side or the other, as the lateral ligaments retain much strength. In a few instances the knee will drop backward to more than a straight line, but, owing to the strength of the crucial ligaments in infantile paralysis, it never falls so far back as to be unable to sustain weight. For the practical purposes of locomotion, therefore, it is only essential that the knee be prevented from dropping forward, and this can be done by means of any appliance which will press the knee backward. The simplest way of doing this is by the use of two steel rods reaching from the back of the thigh to the bottom of the shoe (Chapter XXI., **25**), connected at the top by a posterior steel band, which furnishes a counterpoint of pressure by which to hold the knee. If a strap is passed in front of the knee, it is impossible for it to drop forward when weight is thrown upon the leg, and the patient can stand upon the limb. The appliance supplies the check normally exercised by the muscles. Below it should be fitted to a boot, or, if the muscles of the leg are also involved, to one of the appliances such as the varus or valgus shoe mentioned above.

Instead of being applied by means of a steel sole plate, the apparatus may be fastened to the sole of the boot (Chapter XXI., **26**). In

[1] Gibney: Medical News, 1900, lxxvii., 399.

addition to the bands shown in the figure, leather lacings to retain the thigh and calf will probably be needed to give the apparatus greater stability, as the lacings, by covering a large area of skin, substitute surface pressure for the point pressure given by narrow straps. This is a matter to be considered in all supporting apparatus.

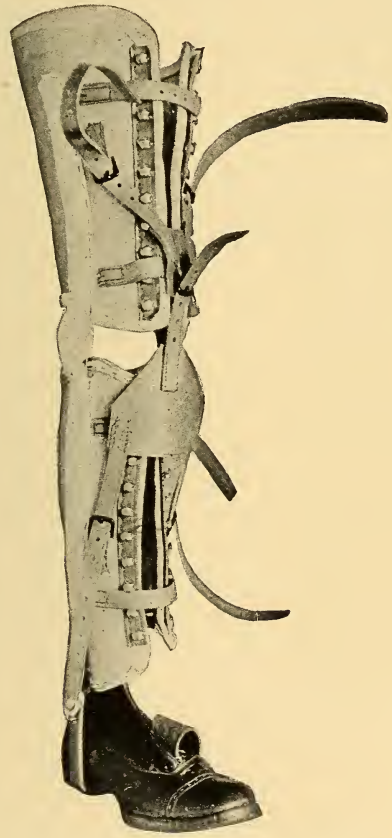


FIG. 384.—Supporting Splint for Infantile Paralysis of the Leg.

FIG. 385.—Supporting Splint for Use in Infantile Paralysis. It prevents flexion of the knee in standing, but is provided with a lock-joint at the knee.

If the knee tends to drop backward and become hyperextended, it can be remedied by a similar appliance with a strap passing behind the knee, with an upper band encircling the thigh. In practice this apparatus can often consist of a single outside upright hinged at the knee. It passes to the inside of the leg just below the knee to become attached to a varus shoe. This answers as well as a double upright in

many cases. The apparatus can be hinged at the knee for convenience in sitting down and should be furnished with leather lacings for the thigh and calf (see Figs. 384 and 385).

Other cases, in which the paralysis is more severe, require the two uprights, as they furnish a more definite support. The foot is easily

FIG. 386.—Jacket Attached to Caliper Splints Applied to a Case of Paralysis of the Trunk and of Both Legs.

retained to the steel sole plate by straps or a piece of leather lacing over the instep. The fenestrated knee cap is the most comfortable method of holding the knee extended.

Although in walking it is generally necessary to have the knee kept extended by the splint, yet in sitting down it is a great comfort to the patient to be able to flex the knee, and for this reason nearly all splints should be hinged at the knee.

A great variety of hinges can be applied at the knee with different catches, enabling the patient to bend the limb by loosening the catch or locking it when it is desired that the limb should be stiff. The simplest and most economical of these is the simple drop catch shown in the figure. When the limb is straightened, the ring falls down and

locks the splint in the extended position, but it can be pulled up at any time, allowing the knee to bend.

In another and more expensive form the splint is self-locking, and the bending is made possible by pressing a handle at the outside of the knee.

When the adductor muscles are affected, little or nothing can be done to supplement them by mechanical means without employing heavy apparatus, inasmuch as their loss of power occurs only in extensive paralysis. Little can be done to remedy paralysis of the glutei muscles, but when paralysis of the legs appears to be complete, a certain amount of relief may be given by attaching the leg uprights to a leather or silicate jacket. The common Thomas knee splint (Chapter XXI., **14**) may be joined to a leather jacket (Chapter XXI., **3**) by lateral uprights jointed at the trochanters.

The muscles of the back are rarely if ever paralyzed, except in connection with palsy of some of the muscles of the leg. Complete paralysis of the muscles of the trunk indicates an extent of disease which is most distressing. When the muscles of the back are but partially affected, help may be afforded by the use of corsets or other supporting appliances, such as are employed in the deformities of the spine. These can be connected with the leg appliances and will afford assistance in standing. Cases of this sort may be so severe as to require the use of crutches for rapid locomotion, but much assistance may be afforded by appliances in many cases.

The abdominal muscles are sometimes, though rarely, affected, giving a protuberant abdomen and a position of much lordosis in standing. Waist bands or corsets will serve to correct the malposition of the trunk to a certain extent.

The mechanical treatment of infantile paralysis of the arm is not a question which arises often enough to make it worth while to enter upon any discussion of it, save to mention that the principles of treatment are the same as those already considered.

The use of elastic bands to supply the place of the disabled muscles is thought in some instances to be sufficient to compensate for the action of the paralyzed muscles. It will, however, be found that an elastic support, inasmuch as it is not of certain tension, is necessarily a varying support and adds to the complicated nature of the appliance rather than to its efficiency, nor is it possible to gauge accurately the force or pressure exerted at any time. It is generally, therefore, a much less efficient form of apparatus than the rigid forms here advocated.

Mechanical Treatment as Applied to the Correction of the Deformity.—Whether the deformity shall be corrected by purely mechanical means or by operative interference depends not only upon the nature

of the distortion, but also upon the time at the disposal of the patient and surgeon. Many of the distortions of this sort can be cured in children without any operative interference, as all that is required is the stretching of the fasciæ and the contracted tendons. These distortions are either flexions at the hip or knee or some distortion of the ankle. The less severe of these distortions yield readily upon the application of efficient force.

Deformity at the hip, which is generally flexion, with perhaps abduction, is the hardest of all the deformities of infantile paralysis to correct by mechanical means, on account of the difficulty of securing a fixed hold upon the pelvis, by which a point of resistance can be secured in overcoming the flexion of the thigh. A simple apparatus which is often of use is furnished by two caliper Thomas knee splints (Chapter XXI., **15**), or one, as the case may be, attached to a leather jacket by side irons hinged opposite to the hips. To the posterior and upper parts of the splints are attached straps which buckle to the back of the

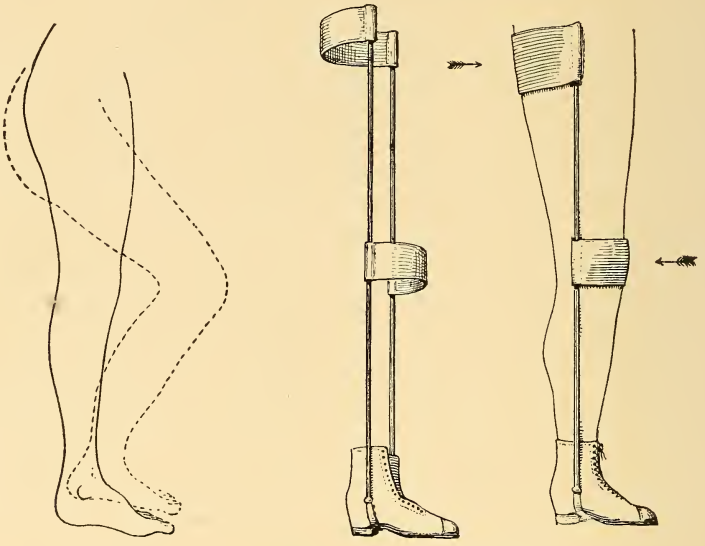


FIG. 387. FIG. 388.

FIGS. 387 and 388.—Supporting Apparatus in Paralysis of Anterior Thigh Muscles.

jacket, and while by the jacket as firm a hold as possible is taken on the pelvis, when the straps are buckled the caliper splints pull the legs backward and tend to overcome the flexion at the hips. During this time the child should go about on crutches.

But the contraction is sometimes resistant, and it is necessary to confine the patient to the bed and to employ traction of a considerable amount and such measures as have already been described in correction of the flexion deformity of hip disease.

Attempts to use the weight of the leg to correct this flexion in severe cases are of little use. It might be imagined that if the knee were straightened by a ham splint, and the patient allowed to go about on crutches with the leg projecting in front of him, the weight of it by dragging upon the shortened tissues would stretch them and the flexion at the hip would be diminished. But the leg hangs almost perpendicularly in these cases, owing to a compensatory lordosis in the lumbar spine, which takes place at once. This is due to the rotation of the pelvis upon its transverse axis, which occurs under the influence of the weight of the leg and which occasions no inconvenience to the patient. A similar proceeding occurs when a weight is applied to the patient's leg lying in bed, so that it becomes inefficient also. In the severer cases operative treatment is indicated.

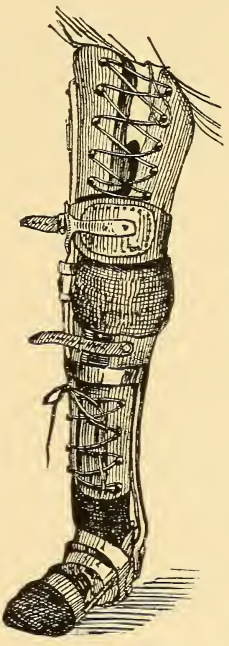


FIG. 389.—Splint with Single Upright for Infantile Paralysis of Right Leg with Varus Deformity of Ankle.

Flexion of the knee is due to a contraction of the hamstring muscles. The deformity in children, except in severe cases, can be corrected by bandaging the leg to a splint which takes pressure above on the under side of the thigh and below is fastened to the heel. The appliance is similar to that described above as a support to the knee. In resistant cases some pain is experienced in this procedure, but the pain is not great. Patients with severe deformity should be confined to bed during the application of this method of treatment, but in the milder cases they may be allowed to go about.

The simplest of all forms of correction in contraction of the knee is the Thomas knee splint (Chapter XXI., **14**) or a modification of it, but jointed splints will be found convenient in some instances of the severest type. If the Thomas knee splint is applied, a bandage should be applied in front of the thigh and behind the calf; by tightening these a decided extension force is exerted upon the knee.

A more complicated brace for correction of the knee is one similar to the simple supporting brace with two uprights already described (Chapter XXI., **26**), except that it is jointed at the knee and furnished on one side with a worm screw and ratchet, so that by the use of a key the splint can be set with any desired angle at the knee. A leather knee cap is sometimes necessary to obtain counter-pressure against the knee in front, but in other cases the thigh and calf lacings are sufficient to obtain any desired leverage. These leather lacings should fit with

especial accuracy in this form of appliance. To be applied the splint should be flexed to fit the contracted knee and put on and laced firmly. Then with the key it should be extended nearly to the point of endurance and worn as straight as it can be borne for an indefinite time. At first these sub-joints may prove sensitive and painful, but they soon become used to the tension and then rapid progress can be made. The extension of a contracted knee may in the case of an adult be a matter of many months, but in children it requires less time, unless it is severe, when operation may be required. The deformity shows a strong tendency to recur when the apparatus is removed.

Correction by the repeated application of plaster bandages to the knee, extended as much as possible, will often be found satisfactory and painless to the patient. This can be facilitated by inserting a hinge joint in the plaster at the knee, and by cutting away the plaster around the leg at the level of the hinges it may be used as a straightening appliance. The method, however, is a slow one in resistant deformities.

Deformities of the Feet.—The mechanical correction of deformities of the foot caused by infantile paralysis is so much more tedious than when operative measures are used that the majority of surgeons much prefer the latter method. In the less resistant cases, however, correction of paralytic cases can be effected by plaster-of-Paris bandages repeatedly applied to feet forcibly held in as near a corrected position as possible. Slight paralytic deformities of the feet can also be corrected by fixing the feet in the walking appliances used for the various forms of talipes, arranged so as to prevent motion in the direction of contraction, but allowing motion in other directions. The weight of the patient at every step acts as a correcting force.

OPERATIVE TREATMENT.

The object of operative interference in paralytic affections is twofold:

1st. To correct existing deformity.

2d. To render the paralyzed limb more efficient.

For average cases of post-paralytic deformity, forcible manual correction with or without the aid of tenotomy, with muscle-stretching and perhaps fasciotomy, are sufficient for correction. The deformities to be corrected are flexions at the hip and knee, and the distortions of the feet classed as the different forms of talipes. The latter can be corrected by the various procedures described in the chapter on "Club-foot." Paralytic talipes, however, is much less resistant and yields to much less radical measures than are often needed in congenital club-foot, and subcutaneous tenotomy and fasciotomy with manual correction will suffice in almost all cases.

Flexion at the knee may require tenotomy of the hamstring muscles, which is more thoroughly performed by means of an open incision than subcutaneously, as frequently the shortened fasciæ need division as well as the tendons. In order to prevent a gaping wound after correction, a Y-shaped or longitudinal skin incision should be used.

An open incision is necessary if the contractions in *flexion of the hip* are resistant. These are usually superficial and involve the fascia lata, but the intramuscular septa of the deep muscles may also need division and the operation may have to be extensive. In the older cases in which alteration in the shape of the bone exists, osteotomy or even excision may be needed. The latter is rarely indicated, as linear osteotomy near the joint will enable

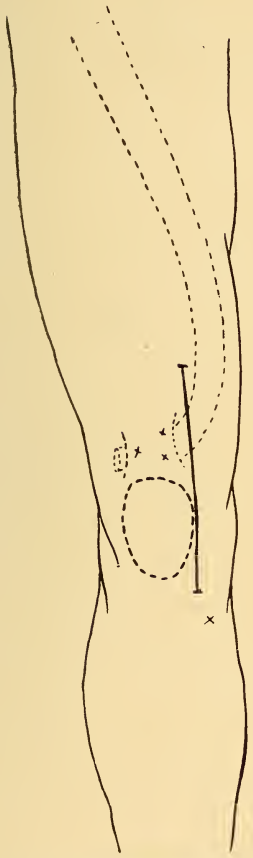


FIG. 390.—Transplantation of Sartorius to Quadriceps Tendon. (Goldthwait.)

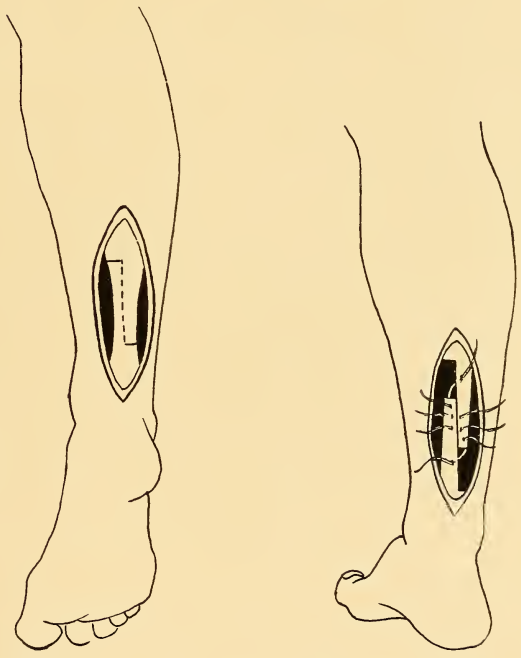


FIG. 391.—Elongation of Tendo Achillis. (Berger and Banzet.)

the surgeon to straighten the limb with less destruction of tissue. The measures above mentioned do not aid the paralysis, but aid locomotion with or without the necessary appliances.

Tendon Transference.[1]—Measures may be undertaken for the direct

[1] O. Vulpius: "Die Sehnenüberpflanzung," etc., Leipsic, 1902 (with bibliography).

purpose of aiding the paralyzed muscles with the view of making locomotion possible without the need of appliances. The most important of these are the operations on the affected muscles.

Tendon transplantation or tendon anastomosis, first introduced in 1881 by Nicoladoni, consists of a procedure by which the proximal ends of healthy or partially affected muscles are inserted in or attached to the distal ends of the tendons of paralyzed muscles or to the periosteum, and the action of the healthy muscle is transferred to the attachment of the paralyzed one or to a more efficient insertion.[1]

The transference of one tendon to another, as originally introduced, has been extensively employed and has been followed by a certain amount of success, but in a large percentage of cases the ultimate results have not been so beneficial as is to be desired. It was found that the functional strength of the transplanted muscle was rarely equal to the required work. Improvements in the methods have been made recently, however, which have increased the efficiency of the procedure.

Periosteal tendon transference, as it may be termed, is a procedure which can be relied upon to give a reasonable amount of permanent success. It is impossible at present to give the statistical value of the procedure. So much depends upon the amount of strength remaining in the transferred muscle that the cases are difficult to group. For success it is essential that the muscular balance in the paralyzed limb be restored, and for this it is necessary that the transferred muscle pass as directly as possible from its origin to its new insertion; it is essential that the transferred muscle should not be relaxed and that it should have a firm and an effective attachment. The transferred tendon should be given a periosteal attachment, if possible, at such a point as will give on muscular contraction the functional result of the required motion. When the tendon is not long enough to reach to the desired point of insertion, it can be lengthened by the use of strands of braided silk, which are quilted in the end of the transferred tendon, and at the distal end sewed into the periosteum or attached to the proximal end of the paralyzed tendon.

Lange, who originated this method, has demonstrated not only that in this way a permanently useful tendon can be furnished, but that apparently fibrous tissue forms about the silk strands. The application of the method varies necessarily with the deformity and the part paralyzed, whether it is for a paralytic talipes equino-varus, a valgus, equinus, calcaneus, for paralysis of the extensor cruris, or for other paralyses.

In *equino-varus*, *equino-valgus*, or *equinus* the procedure is some-

[1] Codivilla: Zeitsch. f. orth. Chir., xii.—Vulpius: *Ibidem.*—Lange, Schanz, and Reiner: *Ibidem.*—Koch: Münch. med. Woch., July 19th, 1904.

what the same. The operation is more conveniently done after the limb has been made bloodless by the Esmarch method, and the deformity of varus, valgus, or equinus must be forcibly corrected with tenotomy and fasciotomy if necessary. The correction of the deformity should be preferably done a few days before the tendon operation. A long incision is then made over the middle of the ankle or the part of the ankle where the tendons to be operated on are situated, extending to the dorsum of the foot. The muscle to be transferred is then selected and the tendon isolated and cut off as near its insertion as possible. The end is then secured by a long, stout, silk suture. The muscular portion is freed above sufficiently to permit a transferrence of the direction of the muscle in a nearly straight rather than a curved course. The desired point of insertion is then selected, which should be as far forward on the tarsus as is practicable. The silk attached to the freed tendon is then stitched securely to the periosteum at the selected point, the tendon pulled tightly into its new position, and firmly tied. If the tendon is too short to reach, its length can be pieced out by the strong silk strands of the suture or it may be stitched into the paralyzed tendon near its insertion, but a periosteal insertion is much to be preferred. All the extensor tendons of the foot, if relaxed, whether paralyzed or not, are to be shortened. If they are paralyzed they can be used as a stay in the corrected position, and if not paralyzed they can only be effective if sufficiently tight. The tendo Achillis should, of course, be divided when necessary.

FIG. 392.

FIG. 393.

FIG. 392.—Transplantation of Tendon. (Berger and Banzet.)

FIG. 393.—Side Incisions in Tendon to Permit Elongation without Loss of Continuity. (Berger and Banzet.)

It is evident that the length and the site of the skin incision varies with the surgeon's judgment and with the muscle to be transferred. Whether the tibialis anticus or the peroneus longus is selected depends upon the location of the paralysis and will affect the position of the skin incision. When the anterior group of muscles are all paralyzed, as in talipes equinus, a portion of the tendo Achillis and one of the peronei can be brought forward to the front of the foot and given an anterior attachment on the tarsus. In this procedure a posterior as well as an anterior incision is needed, and the transferred tendon is passed subcutaneously forward from the posterior to the anterior incision.

The operative reduction of *calcaneus* or *calcaneo-valgus* is not permanently accomplished by simple shortening of the tendo Achillis, be-

cause, being paralyzed, the tendon will again stretch and the deformity recur. If the posterior part of the os calcis is set up toward the ankle, a better relation of the foot to the leg is obtained. The operative procedure is as follows: The side of the os calcis is exposed by an incision sufficiently long and an osteotome is used to loosen the posterior part of the os calcis from the front part. The line of separation begins above, just posterior to the astragalus, and runs downward and forward obliquely. When this part is separated the heel is set up by pressure on the tuberosity of the os calcis. The tendo Achillis is then exposed and reefed until it is tight with the foot in its corrected position.

If an element of valgus exists with the calcaneus, some of the tendons of the common extensor should be cut and given a periosteal insertion into the scaphoid or cuneiform. It may also be advisable to change the insertion of one of the peronei muscles to the inner border of the foot.

In *pes cavus* the plantar fascia is to be tenotomized, the foot forcibly stretched, with an osteotomy of the tarsus in extreme cases. Osteotomy of the os calcis is also to be considered in pronounced varus and valgus with distortion of that bone. The proceeding is similar to that in congenital club-foot.

Paralysis of the Extensor Cruris.—This paralysis can be improved if the hamstring muscles are sufficiently strong. The tendon of the biceps (or a portion of it) and the semimembranosus are freed near their attachments by incision at both sides of the leg, and are brought forward under the skin and stitched securely into the ligamentum patellæ close to the patella. It is necessary that the muscles should be freed sufficiently high up from their attachments so that the muscles can be brought to the front of the leg without being curved.

Transplantation of the sartorius into the conjoined tendon of the quadriceps can be performed, but, as the muscle is not a strong one, as much effective strength cannot be expected from its transferrence as from that of the hamstring. This procedure sacrifices a portion of the power of flexion of the limb at the knee—a loss which is compensated for by the greater usefulness of the limb.

Paralysis of the Upper Extremity.—A portion of the trapezius can be transferred to the insertion of the deltoid in paralysis of the latter. Tendon transferrence in paralysis of the wrist is of value. The same principles of procedure are necessary in the upper as in the lower extremity.

It is almost needless to state that suppuration diminishes the prospect of benefit from tendon and muscle transplantation, and the measure should not be undertaken except by an adept in thorough asepsis.

After-Treatment.—After the operation the limb should be protected by sufficient cotton padding and fixed in the desired corrected position

in a plaster-of-Paris bandage, arranged so as to allow the required inspection after dressing. After six weeks the plaster bandage is to be followed by a retention apparatus, such as has already been described, and the gradually increasing use of the limb allowed, along with massage and passive exercises to develop the transferred muscles to their new work.

Arthrodesis.—Where the paralysis is total or nearly so tendon transferrence is useless, and the disability of the limb, except by mechanical assistance, would be unavoidable were it not for the procedure of arthrodesis, which is devised for the purpose of stiffening the flaccid joint. This is more commonly applied to the ankle-joint and is attempted by opening the joint freely and exposing the astragalus, which should be denuded of cartilage on all its articular surfaces, as well as the lower end of the tibia and fibula. It is necessary that the os calcis should not be free to move under the astragalus, and the joint surfaces of the calcaneocuboid articulation are also to be denuded in very lax joints to prevent a subsequent distortion from the loosening of that joint.

In cases of severely relaxed ankle-joints it is of use to shorten the anterior or other groups of muscles, in order to have them serve as stays to the newly stiffened joint in its resistance to strain.

Arthrodesis can be employed in stiffening the knee and has been employed to fix the shoulder and hip. In the latter joint, however, the operation has hitherto been of doubtful benefit.

After operation the joint should be fixed in a correct position for two months, after which gradually increasing use is to be allowed.

Nerve-Twisting.—It is possible in some cases, where very slight power remains in some muscles of a limb, to increase and distribute that power better by a division and twisting of the main nerve of the limb.

The nerve is dissected out and sutures are passed through the sheath in such a way that, when they are tightened after the nerve is cut, the distal end is rotated on the proximal end through one-third of a circle. The nerve is cut after the sutures are passed, the sutures are tied, and the wound is closed. Decided improvement in function has been reported.[1]

Nerve Transplantation.—It has been demonstrated experimentally by Spitzy[2] that nerve impulses may be given new directions by nerve anastomosis; that is, connecting the proximal end of one nerve with the peripheral end of another and transferring its motor impulse. Peckham[3] transplanted in two cases two branches of the internal popliteal nerve into the external popliteal; in both cases there was some

[1] Verbal communication from Dr. W. S. Baer, of Baltimore.

[2] American Jour. Orth. Surgery, August, 1904.

[3] Providence Med. Journal, January, 1900.

restoration of power in the extensor muscles. J. K. Young, of Philadelphia,[1] has since reported a case of successful nerve transplantation in the leg.

The technique has been elaborated experimentally by Spitzy.[2]

Osteotomy may be required to correct severe flexion deformity at the hip, and at the knee to correct the knock-knee and flexion at the same time. At the hip it does not differ from the ordinary Gant operation, and is necessary only in cases in which division of the soft parts is not enough to allow sufficient extension of the thigh on the pelvis.

At the knee a simple transverse division of the femur is made just above the condyles, allowing correction of both flexion and knock-knee at the same time. These operations, of course, have no effect upon the paralysis as such, but merely serve to place the limb in a position suitable for weight-bearing. After operation mechanical support is usually necessary.

Excision.—In other cases resection of joints is to be considered on account of the extreme bony deformity which they present, as in severe paralytic knock-knee, in which a stiff knee rather than a movable one is desired. If the latter is preferable an osteotomy rather than excision should be done, as excision leaves a stiff joint. The deformity of knock-knee or flexion at the knee can, of course, be corrected by the plane of the bone section in excision.

[1] Am Journ. Orth. Surg., August, 1904.
[2] Zeitsch. f. orth. Chir., xiii.

CHAPTER XV.

SPASTIC AND OTHER PARALYSES.

Spastic paralysis.—Congenital.—Acquired.—Symptoms.—Idiocy.—Etiology of acquired spastic paralysis.—Pathology.—Diagnosis.—Prognosis.—Treatment.—Pseudo-hypertrophic paralysis.—Progressive muscular atrophy.—Hereditary ataxia.—Obstetrical paralysis.

SPASTIC PARALYSIS.

The condition is known under the following names: Spastic paralysis, spastic hemiplegia, Little's disease, spastische Gliederstarre, etc. The affection is more common than was formerly supposed. At the Children's Hospital 310 cases of cerebral paralysis came under treatment, while 987 cases of infantile paralysis appeared during the same period.

Motor disturbances in children which are due to cerebral lesions are manifested clinically in one of three ways: (1) As a single hemiplegia; (2) as a diplegia; (3) as a paraplegia. Contractures, choreiform movements, mental impairment, aphasia, epilepsy, inco-ordination, etc., may be the accompaniments of any one of these forms.

The distribution of paralysis in 225 cases analyzed by Peterson and Sachs was as follows: Right hemiplegia, 81; left hemiplegia, 75; diplegia, 39; paraplegia, 30. Total, 225.

Congenital Spastic Paralysis.

It is usually not recognized at birth, as it consists of a lack of muscular co-ordination common in infancy, which persists in certain muscles during life. The origin of it is to be found in cerebral defects, intra-uterine cerebral hemorrhage, and lack of development of the brain.

Acquired Spastic Paralysis.

Symptoms.—The form most commonly seen is that acquired during or after labor. The onset may resemble very closely that of infantile spinal paralysis; it often begins with an illness of some sort. Frequently paralysis develops in the course of an infectious disease, sometimes after an attack of what seems to be indigestion or a slight feverish attack, sometimes after a fall or a slight blow on the head.

Commonly the onset is marked by convulsions. Delirium or screaming spells may accompany the onset. Sometimes, however, though very rarely, the disease develops suddenly in perfectly healthy children without any febrile or other disturbance, or it may develop insidiously without disturbance enough to attract attention. From the second

FIG. 394.—Case of Right Hemiplegia Attempting to Walk.

FIG. 395.—Attitude in Attempted Walking, Spastic Paraplegia.

year, for the first six or seven years of life, the liability very gradually diminishes; the number of cases, however, rises slightly at the time of the second dentition. In this respect it offers a sharp contrast to infantile spinal paralysis.

When the paralysis is noticed, it is found to be most often hemiplegic in distribution. Monoplegia is rare. The face is paralyzed in a moderate proportion of all cases, and the arm is always affected more severely than the leg and recovers more slowly. The facial paralysis ordinarily is not complete and does not affect the muscles that close the eyes. It disappears first of all the paralyses, and often recovery is complete. Strabismus is very common. The paralyzed side is powerless, but sensation is generally unimpaired; coldness and vascular sluggishness are present in some of the severer cases. The reflexes of the

affected side are much increased from the first—a sign which is of the greatest assistance in diagnosis. As in the hemiplegia of adults, rigidity of the affected muscles comes on in about seventy-five per cent of all cases at a varying time after the onset of the paralysis. The rigidity, when present, is increased by any attempt to use the limb; it is excited by passive manipulation and it disappears during sleep and usually under an anæsthetic. Post-hemiplegic movements follow in a certain proportion of cases. Hemianopsia may be present.

Aphasia accompanies probably a certain proportion of cases of cerebral paralysis, but it is often transitory. It is always motor aphasia and may accompany either right or left hemiplegia.

Mental enfeeblement, varying from complete idiocy to simple backwardness, develops in a large proportion of all cases. In the 26 cases in the Children's Hospital series [1] only 6 had what was classed as average intelligence, and 1 of these was aphasic and 1 stuttered very badly. Of the rest, 7 were idiotic, 8 feeble-minded, and 4 very backward. Sachs found idiocy present in 35 per cent of all diplegias and in 60 per cent of paraplegias, while it occurred in but 13 per cent of hemiplegias. Such children as escape mental deterioration in childhood often develop psychoses later in life.

Epileptic attacks appear in the paralyzed limbs and thence become generalized in one-quarter to one-half of all cases reported. Ordinarily they come on in two or three years after the paralysis, but they may be delayed, and ten or even thirty years may elapse sometimes; on the other hand, they may begin within a few weeks of the onset.

The mind may, however, remain perfectly clear in spite of a severe hemiplegia, and no sign of mental deterioration may be present in the early or the late history of the disease.[2]

To the later history of the affection belong the atrophy and contractions of the limbs. In hemiplegia the affected side rarely recovers entirely, and often the growth of the bones is retarded. The muscular atrophy, as a rule, is not so great as in infantile spinal paralysis, but in certain cases the muscles waste very much. In severe cases there is marked arrest of growth in the bones. In the Children's Hospital series one case showed a shortening of two inches in the arm after the paralysis had lasted seventeen years, and three other cases of four, seven, and eight years' standing showed a shortening of one inch. This points to some trophic lesion.

The permanent contractions that come on are most noticeable in the arm, and as a rule are of one type in the arm and leg. In the former the arm is held close to the side, the elbow is flexed strongly

[1] Lovett: Boston Med. and Surg. Journal, cxviii., 641.

[2] Spiller: "Spastic Spinal Paralysis." Philadelphia Med. Journal, June 21st, 1902.

and firmly, the hand is flexed, and the fingers are drawn into the palm, usually embracing the thumb. The humerus is rotated inward, and outward rotation is resisted by muscular contraction. Supination and extension of the fingers are resisted. These contractions are very firm and resisting. The leg in bad cases is adducted and flexed at the hip, the hamstring muscles of the knee have contracted, and flexion of the knee has resulted, and the foot is in a position of talipes equino-varus or simple equinus. In other cases only the finer movements of the hand may be lost, and the leg movements may be impaired only enough to cause a bad limp.

Post-Paralytic Disorders of Movement.—In certain cases of hemiplegia, single and double, a disturbance of motion occurs at a later stage, which is spoken of under many different names, such as athetosis and chorea spastica; while what is called "congenital chorea" in many cases is the same affection.

Spastic Condition of the Muscles.—At times the tonic spasm of the muscles becomes the most prominent feature of the case, and there is a persistent stiffness and constant spasm of the muscles of the legs and

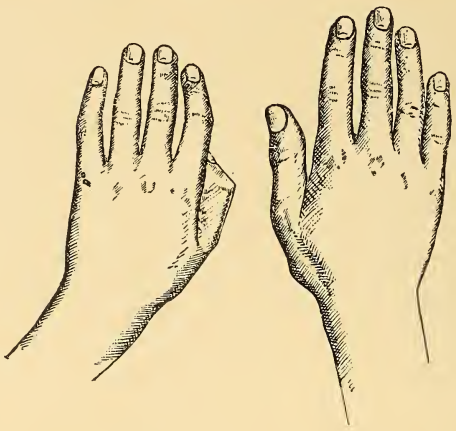


FIG. 396.—Atrophy of the Hand in a Case of Hemiplegia of Several Years' Duration. (Knapp.)

sometimes of the arms; the legs are straight and rigid, and the feet are extended, and when an attempt is made to walk the child stands on tiptoe, and often the spasm of the adductor muscles is so great that the legs are crossed. The walk is almost characteristic—a clinging gait, in which the feet are scraped along the floor with much effort and straining at every step, if indeed the spasm is not so great that walking at all is out of the question.

In general this affection is the result of a cerebral lesion and a descending degeneration of the lateral columns of the spinal cord.

This grade of affection in the majority of cases represents the result

of a larger brain lesion than takes place in hemiplegia. For this reason, these children are for the most part feeble-minded or idiotic—as one might reasonably expect as the result of so extensive a brain lesion occurring at so early an age.

However, one not uncommonly sees children of more than average intelligence affected with spastic paraplegia, so that the existence of spastic paralysis is by no means evidence of mental inferiority.

Often these children have strabismus, a stupid, idiotic face, the saliva drips from the mouth, and the teeth decay very early. In the milder cases the difficulty in walking lies in the fact that

FIG. 397. — Attitude Assumed in Sitting by a Feeble-Minded Child.

FIG. 398.—Spastic Paraplegia in an Adult.

any effort to use the limbs increases the muscular spasm and tends to throw the leg into the position of extreme adduction, with extension of the foot and generally slight flexion of the knees with talipes equinus. It is often impossible to demonstrate the increased tendon reflexes either at the knee or at the ankle on account of the great stiffness of the legs, because the muscles are continually at their maximum of contraction. The electrical reaction in these and in the hemiplegia cases is unchanged.

In certain cases the spasm is so great that the patient is unable to

stand alone. When supported, the thighs are adducted very closely and the toes pointed and crossed.

The mental disability may be manifested in the milder cases by an excessive irritability and a disposition to do mischief and perhaps to destroy playthings wantonly. Furious outbursts of temper are not uncommon.

It seems as if spastic paralysis of the legs were occasionally a sequel of simple hemiplegia coming on after some years.

Inco-ordination or Idiocy.—This condition may be the accompaniment of cerebral palsy or it may be the result of other causes.

The classification of Sachs is as follows:

1. Hereditary idiocy { (*a*) congenital. (*b*) developmental.
2. Acquired idiocy { after traumatism. after convulsions. after infectious diseases.
3. Myxœdematous idiocy.

The only excuse for its introduction here is the very close outward resemblance that these conditions present on superficial examination to the spastic cases already considered; but definite paralysis and spastic rigidity of the muscles are absent, and idiocy obscures everything. If patients are seen seated, the stupid cross-eyed look, the drooping head,

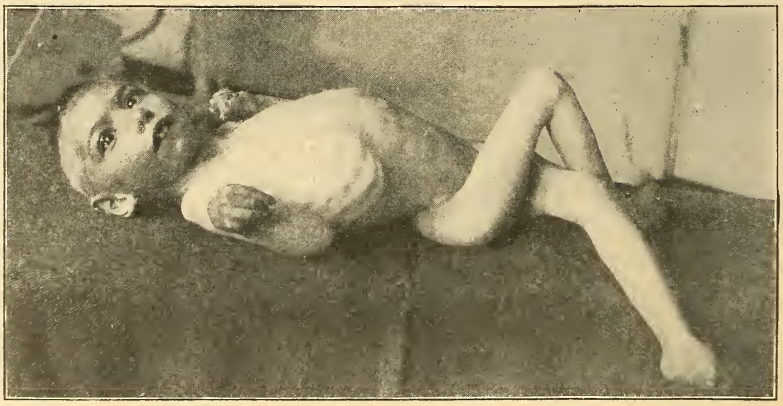


FIG. 399.—Severe Infantile Spastic Paralysis.

and the drooling are exactly what is seen in the severe mental enfeeblement of spastic paralysis or hemiplegia. But put the child on his feet and the difference is at once evident. Either his muscles are so lax that he will be unable to bear his weight at all, or he will stand holding his parent's hands with his feet wide apart, his knees bent, and

his trunk leaning forward. The whole body sways to and fro with an oscillating movement, and the sense of equilibrium seems almost wanting; if he is let alone, he walks in a staggering, uncertain way, with many falls. From this the condition grades off to a disability so great that the child cannot even sit up; when it is propped up the head lops on to one shoulder, the vertebral column fails to support the trunk and bends to a marked degree, and every muscle seems limp and useless. There is no suspicion of muscular rigidity or localized paralysis.

Sensory disturbances are not uncommon, and often a pin can be thrust through the skin without pain. The reflexes are sometimes normal and sometimes increased, while the legs are generally flabby and cool, and the hands and feet often undeveloped. Every grade of the condition is seen from that described above to complete helplessness.

Etiology of Spastic Paralysis.—The etiology of prenatal cases of cerebral palsy is obscure. Such cases may occur in neurotic and epileptic families. Traumatism to the mother during her pregnancy, severe illness of the mother, severe fright, and hereditary syphilis are among the causes. The etiology of cases dating from birth is better formulated. Asphyxia at birth, prolonged labors, and instrumental deliveries are frequent causes.

In cerebral paralysis acquired after birth there are certain well-formulated causes.[1] Acute infectious diseases play their part, cases having occurred after measles, scarlatina, typhoid fever, smallpox, tonsillitis, pneumonia, pertussis, cerebrospinal meningitis, gastro-enteritis, mumps, diphtheria, dysentery, typhus fever, and syphilis. Fright and trauma are two other accepted causes.[2]

In a large number of cases the disease seems to affect perfectly healthy children without any assignable cause. The indigestion attacks, the fever, and the convulsions attending the onset cannot fairly be assigned as causes. The disease is about evenly divided between the sexes.

Pathology.—The pathological condition is much the same in hemiplegia, diplegia, and paraplegia. These conditions in general are due to embolism or hemorrhage, and the resulting retardation of growth of the affected portion of the brain, together with the secondary changes in the spinal cord. Autopsies made later in the disease show pathological changes which are more extensive and less definite in their character. Wasting and sclerosis of a greater or less part of the brain and the con-

[1] Phila. Med. News, 1887, ii.—Parvin: American Journ. Med. Sci., 1875.—Sinkler: Med. News, 1885, vol. i.—McNutt: Am. Jour. of Obst., 1885.—Parrot: "Clinique des Nouveau-nés," Paris, 1877.

[2] Obstet. Trans., London, vol. xxvi.; Boston Med. and Surg. Journal, June 28th, 1888.—Osler: Phila. Med. News, July 14th, 1888.—Abercrombie: St. Barth. Hosp. Rep., xvi., p. 35, and Brit. Med. Journ., June 18th, 1887.

dition known as porencephalus are what one finds in these later cases. These seem to be the late results of the destructive change mentioned above, which have occurred in a growing brain and have retarded its growth and have produced an extensive scar formation in the place of cerebral tissue. Porencephalus occurs as a loss of substance in the form of cavities or cysts.

The pathology of the condition [1] is a lesion of the motor tract of the brain with consequent atrophy and retarded development of the affected portion, and descending degeneration of the pyramidal tracts and lateral

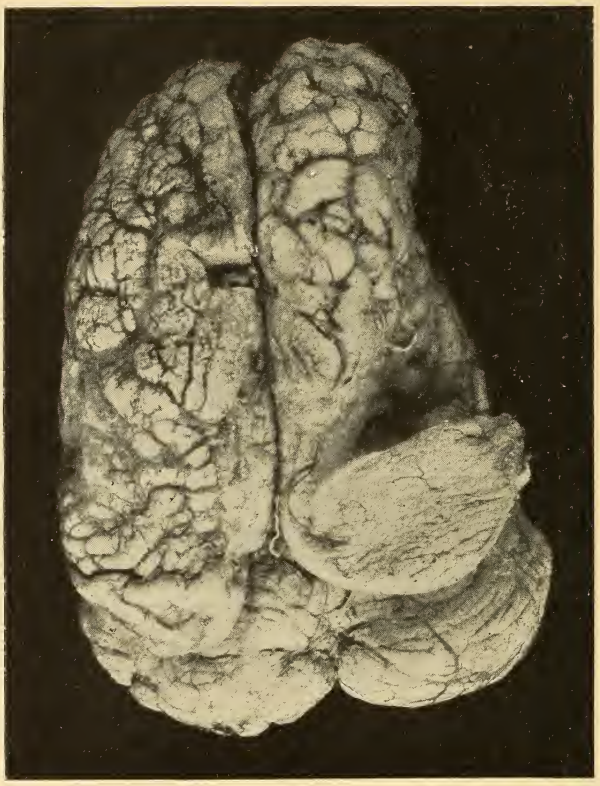


FIG. 400.—Distorted Brain in Case of Infantile Spastic Paralysis.

columns of the cord. From the extensive atrophy found in young children at autopsy, it seems that unquestionably sometimes the disease originates in defective development of the nervous centres, especially the pyramidal tracts, rather than in an acute cerebral hemorrhage or embolism.

The theory that the condition was due to a poliencephalitis similar

[1] E. H. Bradford: Am. Journ. of Orth. Surgery, vol. i., p. 375.

to poliomyelitis has not received confirmation nor the support of modern neurologists.

To enter upon a discussion of the pathological condition in the cases of inco-ordination spoken of above would be to introduce the very extensive subject of the pathology of idiocy.[1]

Diagnosis.—Spastic paraplegia is characterized by tonic contraction of the muscles which yields to steady resistance, except in the advanced stages where fibrous changes have taken place. The galvanic reaction is normal. At times the muscular rigidity is so excessive that the exaggerated knee-jerk and ankle clonus cannot be obtained. In estimating the child's mental condition, very little weight can be attached to the parents' account of the patient's capacity.

The differentiation of cerebral paralysis and infantile spinal paralysis has been dealt with.

Obstetrical paralysis might be mistaken for a cerebral lesion, but a careful examination would determine the paralysis to be limited to the distribution of some especial nerve or group of nerves. It occurs in the distribution of the facial nerve after the use of the forceps, but it occurs as a rule in the shoulder in consequence of the stretching of the nerve trunks in the manual extraction of the child's body.

Cerebral tumors may cause the symptoms of hemiplegia, and a diagnosis of this condition from the lesions generally causing paralysis would ordinarily be impossible. Tumors of the pons or cerebellum would cause symptoms of bilateral rigidity (spastic paraplegia) if they compressed the motor tracts.

Pseudo-hypertrophic paralysis, the pseudo-paralysis of rickets, syphilis of the spinal cord, and hereditary spastic paralysis are possible sources of an error of diagnosis in obscure cases. Certain cases of chorea prove on investigation to have their origin in a slight cerebral paralysis. The same may be said of epilepsy.

Prognosis.—The prognosis in these cases should be most guarded, and is dependent upon the extent of the central lesion, not always easily recognized. When epilepsy or idiocy is present little benefit can be expected from surgical treatment. The spastic muscular condition is to be regarded as a difficulty in addition to the epilepsy or idiocy which especially needs treatment. When no mental impairment is present much benefit can be expected from suitable surgical treatment.

In formulating the prognosis it is to be remembered that epilepsy develops in about half of the cases.

[1] Osler: Med. News, Phila., August 11th, 1888, p. 143.—Landouzy and Siredey: Rev. de Méd., 1885.—Jendrássik and Marie: Arch. für Phys., 1885.—Gowers and Handford: Brit. Med. Journal, 1887, i., 1098.—Seibert: Arch. of Pediatrics, March, 1888, 168.

Treatment.—In spastic paralysis it is at times possible to accomplish much by muscular training and exercise. The muscles which are most strongly contracted are the thigh adductors and the calf muscles. Such a patient should be given exercises calculated to develop the abductor muscles and the dorsal flexors of the foot, which by increased power will in a measure counterbalance the muscles which are too powerful. The patient should lie on the back on a hard table, and should separate the legs as far as possible at first without being touched, and then against slight resistance. The legs in the extended position should be rotated outward, while the heels are kept together. In walking the patient should be cautioned to go very slowly, to lift each foot well off of the ground, and to turn out the toes with much care. In connection with massage and rubbing, this method of treatment is capable of accomplishing a decided change in the method of walking, and, while the walk may be stiff and unsteady, it has lost the characteristic scraping and dragging of the spastic gait. Such patients walk with much less fatigue than before and feel much more steady upon their feet.

FIG. 401.—Spastic Paralysis before Operation.

The disappearance of the aphasia is aided by systematic training and it always proves more tractable than in the adult.

Apparatus is suited to the treatment of the milder deformities only. Talipes equino-varus of a mild degree may be temporarily corrected by a proper appliance (Chapter XXI., **27**). The muscles furnish sufficient support to the affected limbs, but, owing to the increased reflex excitability and to imperfect motor impulses, the muscles are in a state of spasm and of uselessness from the distorted position. In general the deformities are to be treated as in infantile paralysis. The deformity, however, returns immediately on removal of the appliance, so that, apart from the temporary rectification, apparatus is of little advantage in cerebral paralysis. Retentive apparatus, however, is of use in retaining the limbs

in proper position after operation (Chapter XXI., **25**). Post-hemiplegic movements are at times relieved by placing the member at rest for some weeks or months under restraint.

Operative Treatment.—*Tenotomy, Myotomy, Fasciotomy.*—Clinical evidence has proved that tenotomy, especially of the tendo Achillis, in this class is of great benefit in suitable cases, not only in improved walking, but sometimes in improvement of the general condition and diminution of the general irritability, from the benefit of increased ac-

Fig. 402.—Spastic Paralysis after Operation.

tivity. The orthopedic surgeon will meet a certain number of cases of this class with pronounced equinus deformity of one or both feet. Locomotion is difficult for the reason that it is impossible for the patient to bear the weight upon the whole sole of the foot. This increased difficulty is sometimes sufficient to deter the patient from efforts at locomotion and always adds to the unsteadiness of gait. If tenotomy of

the tendo Achillis is done, the contraction ceases, and though the strength of the muscle is not lost in a number of cases which have been watched by the writers for several years, there is little tendency to a reappearance of the equinus deformity.[1]

In instances of this sort a practical cure may be gained by tenotomy. This treatment is especially suited to those cases in which there is little or no mental disturbance.

Division of the hamstring tendons by open incision should be done when they are sufficiently contracted to prevent the full extension of the knee. This operation is preferable to subcutaneous tenotomy because it offers a better chance to divide contracted tissues other than tendons.

In the severer cases with adductor spasm division of the adductor tendons is also of benefit, as the adductor spasm often causes the knees to knock together in walking and is a serious obstacle in progression, and even the weakening of the muscles spasmodically contracted by removal of a portion of the muscular bellies is often of use. Gibney[2] has removed the tensor vaginæ femoris with benefit to correct the inversion of the limb not infrequently met. In many instances, however, if the intermuscular septa and the intermuscular fasciæ are thoroughly divided in the spasmodically contracted muscular area, the remaining portion of the muscle can be overstretched.

After-Treatment. — After the operation the limb is to be fixed in an overcorrected position by means of plaster-of-Paris bandages or retentive appliances for several weeks. This is to be followed by muscle training, gradually increasing exercises, with limbs held by ambulatory retention appliance (similar, as a rule, to what are to be used in infantile paralysis) until the proper muscular balance has been established, when appliances are to be discarded.

It is to be remembered that the affection is not strictly a paralysis, but a disability from imperfect muscular co-ordination, increased by muscular contraction in certain muscles. The treatment consists in not only restoring the muscular balance, but in muscle training to re-establish the proper muscular co-ordination. Care is necessary during the process of muscle training with apparatus not to overstretch the divided tendons, as, for example, after division of the tendo Achillis, as locomotion with stiffened knees, necessary in the earlier stages of after-treatment of a contracted limb, brings unusual strain upon the tendo Achillis. It is advisable, therefore, in tenotomy of this tendon (where hamstring contraction exists), to perform plastic tenotomy. This is done by dividing half of the tendon at different levels and on different

[1] O. Vulpius: "Die Sehnenüberpflanzung," etc., Leipsic, 1902, p. 197 (with bibliography).

[2] American Journ. of Orth. Surgery, vol. ii., No. 1.

sides, and by stretching the tendon, elongating it without leaving a gap entirely across.

Tendon transferrence has been recommended in this affection, especially of the hamstrings forward, to reinforce the lengthened extensor curis by a procedure similar to what is employed in poliomyelitis. This would avoid the need of muscle training, with, however, a loss of the muscular balance which is always desirable. The procedure should be reserved for the more severe cases.

Tendon transferrence, however, is of great advantage in the spastic contraction of the forearm.

Arm and Hand.—The pronator radii teres may be converted into a supinator,[1] and the carpal flexors may be converted into carpal extensors.[2] In the first operation an incision, two or three inches long, is made in the middle of the front of the forearm. The upper and corner borders of the pronator are cleared and the tendon with its periosteal attachment is freed from the radius. The tendon is then passed through the interosseus membrane close to the radius and the tendon reinserted on the outer side of the radius, if possible at the site of its former insertion; if not, at a new roughened place on the radius.

In the other operation[2] the flexor carpi ulnaris is divided just above the annular ligament and inserted into the tendon of the extensor ulnaris, and the flexor carpi radialis divided at the same level and attached to the radial extensor.

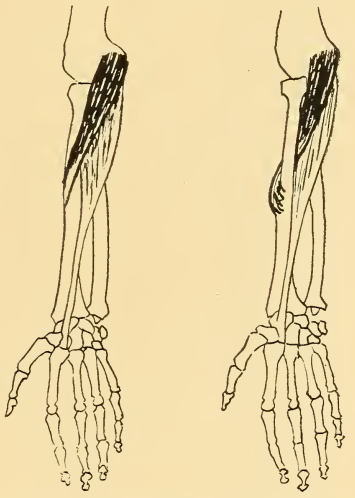


FIG. 403.—Transplantation of the Pronator Radii Teres in Spastic Paralysis of the Arm.

Operations upon the Brain.—It is natural that exploratory trephining should be attempted in cerebral paralysis when the lesion can be well localized. Little benefit, however, has as yet followed this procedure in spastic paralysis, for the reason that the degenerative changes following the congenital defect are such as are not relieved by operative interference. It is possible, if the operation could be performed at an early stage shortly after birth, that benefit might result.

There are certain motor disturbances affecting children which come under the notice of the orthopedic surgeon so frequently that a brief

[1] A. H. Tubby: Brit. Med. Journ., September 7th, 1901.

[2] Robert Jones: Tubby and Jones, "Surgery of Paralyses," London, 1903, p. 225.

mention of their characteristics deserves a place here. These affections are:

I. Pseudo-hypertrophic muscular paralysis. Progressive muscular atrophy.

II. Hereditary locomotor ataxia.

1. PSEUDO-HYPERTROPHIC MUSCULAR PARALYSIS.

Definition.—Pseudo-hypertrophic muscular paralysis is an affection of the muscular system characterized by a diminution or loss of the functional energy of certain muscles and an abnormal increase in their size, which, together with diminution in the size of other muscles, is pathognomonic. The affection is also known as muscular pseudo-hypertrophy, lipomatous muscular atrophy, diffuse muscular lipomatosis, myopachynsis lipomatosa (Uhde); Paralysie myosclérosique, paralysie musculaire pseudo-hypertrophique. Modern classification places the affection among the progressive muscular atrophies.

Etiology.—The etiology of the affection is not known. The disease develops usually during childhood, but in exceptional instances its appearance is delayed until the age of eighteen or twenty years. It affects males more commonly than females in about the proportion of four or five males to one female. The disease is more apt to occur in family groups than in isolated cases, and the hereditary element is marked.

Pathology.—The pathological condition consists in the overgrowth of the connective tissue in the muscles and the wasting of the muscular substance proper, while a deposit of fat takes place to a greater or less extent. No constant or characteristic pathological condition is found in the spinal cord, although various changes have been described, and the condition is at present still regarded as a primary affection.

Symptoms.—The first symptoms to attract attention to the child's condition are muscular feebleness and peculiarity of gait. These generally precede any noticeable enlargement of the muscles. Such children tire very easily in walking and they have especial difficulty in going up and down stairs. They fall often and in rising from the ground they adopt a procedure which is one of the most characteristic features of the disease. Inasmuch as on account of muscular weakness they cannot straighten the back or extend the knees without assistance, they rise from the ground in the manner shown in Figs. 406, 407, using the muscles of the arms to accomplish what the leg and back muscles cannot do.

These children tend to walk with legs apart, and at times an awkward gait and a tendency to fall are for a long period the only symptoms of the affection.

Such patients learn to walk late and depend much in their progress upon the assistance afforded by the furniture, upon which they lean heavily. In kneeling on the hands and knees at times there may be noticed a characteristic saddle-shaped depression of the back, which is due to the weakness of the erector spinæ muscles. This is not an early accompaniment of the disease, but is a characteristic of the late stage when much lordosis is also present in standing.

In walking these children throw the centre of gravity of the body well over each leg in turn as it supports the body-weight. In this way they save muscular effort. The result is a waddle more or less

FIG. 404.—Kyphosis in Pseudo-hypertrophic Paralysis.

FIG. 405.—Case of Pseudo-hypertrophic Muscular Paralysis.

marked. They may stand with marked lordosis of the lumbar spine, chiefly due to a weakness of the lumbar muscles. The lordosis disappears when the patient sits down and a bowing backward of the whole vertebral column takes its place.

Mental enfeeblement is associated with the disease in many cases. The enlargement of the muscles is usually most marked in the calves of the legs. On this account the parents generally feel no anxiety because the child walks late or feebly, inasmuch as the development of the legs seems so remarkably good.

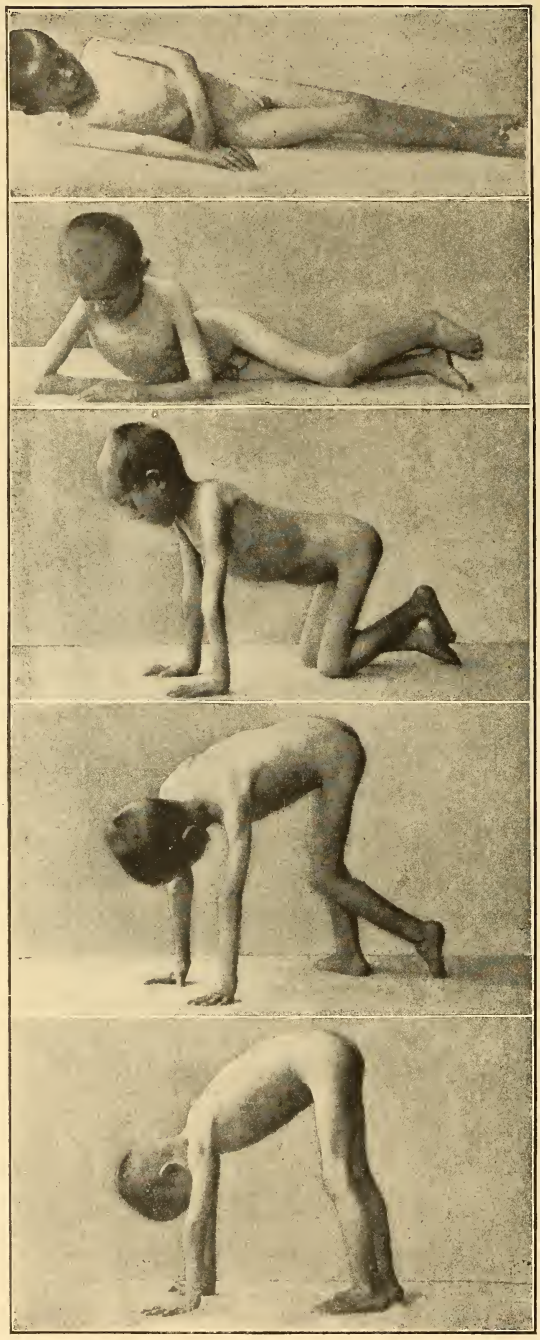


FIG. 406.—Series of Photographs Showing Method of Getting up from the Ground in Pseudo-hypertrophic Muscular Paralysis. (Curschmann.)

The affected muscles are hard and resistant to the touch, but at times the sensation in handling them is like that of a fatty tumor.

Atrophy of some of the muscles of the upper extremity is apt to be present. The scapular muscles, the serrati, the latissimus dorsi, and the pectoralis major are often wasted.

Talipes equinus and flexion of the knees and hips may occur from muscular contraction. Lateral curvature of the spine may follow, and at other times a permanent flexion of the spine occurs from weakness of the erector spinæ muscles, and the child sits bowed forward. But these deformities mark only the late stage of the affection, which is more often characterized by a helplessness more or less complete.

Neither the reflexes nor the electrical reactions are modified in any degree until the muscles have reached a marked stage of atrophy. Then they are dimin-

ished in proportion to the muscular wasting, and finally they are lost. The reaction of degeneration is not present. Very often the skin over the affected limb is mottled and subject to vascular changes, indicating some vasomotor disturbance.

Diagnosis.—In well-defined cases the affection in its later stages is not likely to be mistaken for anything else. The peculiar gait with the feet wide apart and a reckless disregard of falls, the characteristic method of rising from the floor, the age of the patient, and the progressive character of the disease, all suggest this affection. If examination shows enlargement of the calf muscles and normal or diminished reflexes, the diagnosis may be considered as established. Yet of even greater diagnostic importance than the enlargement of the calf muscles is the combination of enlargement of the infraspinatus and wasting of the latissimus dorsi and pectoralis

FIG. 407.—Series of Photographs Showing Method of Getting up from the Ground in Pseudo-hypertrophic Muscular Paralysis. (Curschmann.)

major muscles—a state of affairs to which great diagnostic importance is to be attached.

The gait in early hypertrophic paralysis, and that in idiocy, spastic paralysis, in the paralysis of rickets and Pott's disease, and in simple weakness have very much in common.

Prognosis.—The prognosis is as unfavorable as possible. Recovery is all but unknown,[1] and arrest of the disease is rare.[2]

The course of the disease is essentially chronic. The earliest stage is made manifest by muscular feebleness, and passes on to a stage in which hypertrophy of the muscles becomes evident. This stage is progressive and at the end of it the pseudo-hypertrophy reaches its maximum and the disease becomes stationary and remains so for two or three or perhaps several years. Then comes a time of increasing feebleness and extension of the paralysis. The muscles waste and the power of movement is lost in the legs and arms. In this deplorable condition the patient may live on until death comes from increasing exhaustion or some intercurrent disease.

Treatment is practically without benefit, and there is no reason to believe that drugs have any effect in retarding its progress. Electricity, massage, and gymnastics are sometimes of benefit in connection with other treatment.

Tenotomy is of use as soon as the heels are drawn up. Often walking may become impossible, chiefly on that account, and division of the tendo Achillis on both sides may restore for a time the power of walking; also tenotomy of the hamstring tendons at the knee may be indicated in severe cases.

PROGRESSIVE MUSCULAR ATROPHY.

Progressive muscular atrophy is an affection characterized by a wasting of the voluntary muscles, and a consequent diminution in their power, which pursues a chronic course and attacks successively individual muscles and groups of muscles.

Etiology.—In muscular atrophy as it occurs in children, the only cause assignable is a congenital tendency, often inherited. But at times isolated cases are met, and in adults other causes are to be taken into account.

Males are more often affected than females, and the time of onset of the disease is most variable; it may begin as early in life as at the age of three years or as late as sixty, but its development in advanced life is rare.

[1] Duchenne: Arch. gén. de Méd., 1868, i., pp. 5 and 6.

[2] Donkin: "Note on a Case of Pseudo-hypertrophic Paralysis, Recovery." Brit. Med Journal, April 15th, 1882.

Progressive muscular atrophy has, since the days of Aran and Duchenne, been subdivided into different types.

1. In the Aran-Duchenne type the atrophy begins oftenest in the small muscles of the hand, spreads to the forearm and perhaps the shoulders and back. It may begin in the muscles of the thighs. The atrophied muscles show fibrillary contractions, and the reaction of degeneration is present.

The affection has a pathology and is of spinal origin. The changes found are a sclerotic and pigmentary atrophy of the ganglion cells of the anterior cornua, an inflammatory condition of the neuroglia, and cellular proliferation. The anterior nerve roots are affected secondarily.

2. The hereditary form is of the same general type as the preceding. It is very unusual and may occur in more than one member of a family.

3. The peroneal form or leg type of progressive muscular atrophy affects in most cases the lower extremities. The extensor muscles of the toes are first affected, then the small muscles of the feet, and finally the entire leg. Talipes equinus or equino-varus is a common result. The development of double club-foot with progressive wasting of the lower extremities is very suggestive of this type of the affection. It may affect the upper extremities first and then the lower.

Sensory changes are generally present. The reflexes in the lower extremities may be diminished or lost if the disease is sufficiently advanced. The electrical reactions, as a rule, are altered both quantitatively and qualitatively. Cases of club-foot occurring in this type may be successfully operated on.[1]

The changes in the muscles consist in atrophy of the fibres, a loss of transverse striation, and a proliferation of the nuclei. Degenerations of the nerves are present, but changes of importance in the spinal cord have not been established.

The two remaining types along with pseudo-hypertrophic paralysis are to be classed as primary myopathies or primary muscular dystrophies, in that they are not associated with demonstrable lesions in the spinal cord.

4. Erb's type. The juvenile form of progressive muscular atrophy is very rare and is characterized by progressive wasting of certain groups of muscles. These are the muscles of the shoulder girdle, the upper arm, the pelvic girdle, the thigh, and the back. The forearm and leg muscles remain, for a long time at least, intact. There are no fibrillary contractions, no reaction of degeneration, and no sensory disturbances.

5. The Landouzy-Dejerine type or the facio-scapulo-humeral variety occurs at times in children. The muscles of the face are first affected and the atrophy spreads to the shoulder and arm muscles. In excep-

[1] Sachs: *Loc. cit.*, p. 413.

tional cases this type may begin in the arms or legs. The reaction of degeneration and fibrillary twitching are never present.

Treatment.—The medical treatment of all these affections is hopeless. When muscular contractions occur tendons should be cut and deformities rectified. Rest to the atrophied muscles, massage, and electricity are useful.

HEREDITARY ATAXIA.

Hereditary ataxia deserves mention as a serious motor disorder which is sometimes met in children. It is dependent upon a family predisposition, but is not often directly inherited, but more commonly appears in several members of one generation. Hence the name of family ataxia. It is also known as Friedreich's disease. Other names are hereditary ataxic paraplegia and degenerative ataxia. The cases are rare.

Etiology.—Aside from the influence of a congenital tendency the cause of the disease is as yet unknown.[1] The disease develops most often early in life. The sexes seem equally liable to the affection.

Pathology.—In examining sections of the cord in these cases, a degeneration of the lateral columns, with a more intense and plainly marked sclerosis of the posterior columns, is found. This is similar to the lesion of locomotor ataxia.

Symptoms.—The symptoms resemble very closely those of locomotor ataxia, except that the lightning pains of the early stage and crises

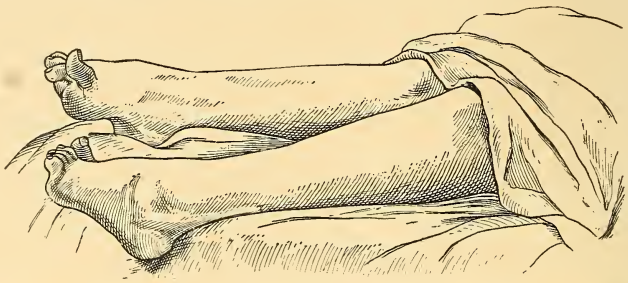


FIG. 408.—Deformity of the Feet in a Case of Friedreich's Disease. Hyperextension of the toes and club-foot. (Marie.)

are not so marked as in the latter affection. Hereditary ataxia, moreover, involves the upper extremities more severely and earlier in the course of the affection.

The patient notices a feeling of weakness and uncertainty in walking, and soon it becomes apparent to others that the motions of the legs are not properly co-ordinated. The feet are placed wide apart in standing, and in walking the gait is practically that of locomotor ataxia.

[1] Gowers: Vol. i., p. 380.—Shattuck: Bost. Med. and Surg. Journal, vol. cxviii., 7, p. 168.—Smith: Boston Med. and Surg. Journ., October 15th, 1885.

The movements of the hands become irregular and inco-ordinate, and a jerky irregularity develops in the movements of the head and neck, so much so that it may assume the aspect of an irregular tremor. Speech may also be impaired.

The knee-jerk disappears, but the plantar reflex remains. Sensation is affected in varying degrees in different cases, and trophic disturbances of the skin are not present. As a rule the sphincter muscles are not affected. Nystagmus is often present; the Argyll-Robertson pupil is absent.

Deformities are apt to come on in the later stages of the disease. Lateral curvature may be present; talipes equinus or equino-varus and permanent flexion of the knee are likely to occur.

Diagnosis.—In a clearly marked case the walk is characteristic and resembles that of ordinary locomotor ataxia. The deep reflexes are diminished or absent and there is a certain amount of disturbance of sensation; the electrical reactions are normal. Isolated cases occur rarely, and a history of some such affection in other members of the same family aids very much in the diagnosis.

Prognosis.—The disease is essentially progressive, and the prognosis is bad in proportion to the rapidity of progress. Death usually occurs from intercurrent affections, but sometimes the disease lasts for thirty years or more and does not seem to have shortened life. It is not likely to cause death inside of ten or twelve years at the least, and nothing can be expected from treatment.

Treatment.—The treatment should be similar to that in common use in locomotor ataxia. The general hygiene of the patient should be most carefully regulated, and skilful massage sometimes accomplishes much in keeping up the nutrition of the muscles and thus diminishing the patient's disability. Electricity in the same way is of use, but it is distinctly second in importance to proper massage. Deformities should be corrected by tenotomy, etc., as they occur.

Among similar affections are *the cerebellar type of hereditary ataxia* described by Marie, differing chiefly in having exaggerated reflexes and ocular symptoms in addition to those described above.

OBSTETRICAL PARALYSIS.

Obstetrical paralysis of the shoulder is an affection which is fairly common and often results in a disabled arm. It occurs most often after difficult labors when traction is made upon the head in head presentations, or upon the trunk when the head is delivered last. It may occur, however, after normal labors.[1]

The injury appears to be due to injury to the two upper roots of the

[1] Boston Med. and Surg. Journal, 1892.

brachial plexus. It has been found experimentally that the two upper roots give way first when traction is made, becoming very tense when the shoulder is pulled down, while the three lower roots remain lax under the same conditions.[1] The paralysis is of Erb's type and the nerves involved are the circumflex, suprascapular, musculo-cutaneous, and musculo-spiral.

The condition is made manifest immediately after birth by an inability to use one arm; it hangs powerless at the side, with the palm turned backward, and often the fingers are flexed tightly. If the arm is lifted from the side it falls lifelessly back into place, and although movement of the fingers is generally present, it is impossible to use the arm to any extent on account of the paralysis of the shoulder muscles.

The *prognosis* in the severer cases is not good as to recovery.

The *treatment* should consist in the use of a sling or supporting bandage at first to prevent stretching of the joint capsule and muscles. Later massage and electricity are likely to be of use in lighter cases. The muscles should not be allowed to acquire a permanent contraction, but should be kept lax by daily manipulations of the joint. External rotation and supination are the most difficult motions to preserve.

In cases with contraction, myotomy of the pectoralis major muscle followed by retention of the arm in a position to prevent contraction of the scar, is of use.

When the paralysis affects only certain muscles, as is not infrequently the case, operative measures, referred to in the chapter on "Spastic Deformities," viz., muscle transferrence, will be of assistance. Portions of the trapezius can be transferred to the deltoid, and other muscular transferrence can be performed in the forearm if any strong muscles remain.

If the biceps is paralyzed and no triceps can be utilized, the arm can be made more useful by a procedure suggested by Jones, of Liverpool, viz., a flap plastic operation in the bend of the elbow, the skin and resulting scar tissue serving to hold the arm in a slightly flexed position, which is more useful than a straight one. Arthrodesis can be performed for the same purpose at the elbow.

[1] J. S. Stone: Boston Med. and Surg. Journ., 1899.

CHAPTER XVI.

FUNCTIONAL AFFECTIONS OF THE JOINTS.

Definition.—Etiology.—Occurrence.—Symptoms.—Spine.—Hip.—Knee.—Ankle.—Diagnosis.—Prognosis.—Treatment.

DEFINITION.

Functional disorders of this class are also termed hysterical and neuromimetic.

The affections of this class most often involve the spine, hip, knee, and ankle, although the other joints can hardly be considered exempt.

These disorders are probably dependent upon a disturbed nervous condition, perhaps due to a disordered blood supply, brought about by nervous exhaustion from overgrowth, from disease, nerve strain, or from trauma. They are here termed functional, because there is no evidence, clinical or pathological, of organic disease. Ordinarily these disorders are seen in persons of an excitable, emotional temperament, but exceptionally the most aggravated type of functional affections may be seen in persons of calm and composed demeanor manifesting no exaggeration in statement or manner.

ETIOLOGY AND OCCURRENCE.

A study of the etiology of this class is disappointing. As a predisposing influence, an emotional temperament, which enters largely into the exaggerated statement of all subjective symptoms, must be considered in all cases. The influence of home training and discipline in the development of this temperament is important, as well as is heredity. Persons broken down in health by suffering or chronic disease become naturally in time incapable of bearing pain, and the statement of such patients is exaggerated and the endurance lessened.

Trauma is a frequent exciting cause. In certain cases the pain caused by a synovitis, for instance, seems to be perpetuated after its legitimate cause has disappeared. This is due to the patient's abnormal sensitiveness and self-concentration. Such sensations are to be classed as "habit pains."

Again, slight sources of peripheral irritation, too slight to be an inconvenience to normal persons, may be a cause of severe symptoms in neurasthenics. Among such causes may be mentioned a short leg

or a weakened foot of slight degree, some degree of thickening of the synovial fringes in the knee, etc.

This condition of hypersensitiveness is sometimes to be seen in young girls about the time of puberty, and in elderly women at the time of the menopause, rarely in young children. Women in young and middle adult life are the most frequent sufferers. How far sexual irritation enters into these cases as a causative influence cannot be said with certainty, but in some cases it appears to be one of the disturbing factors which make up the disease. The statement cannot be too strongly made that, although these affections are seen mostly in young women at or after puberty, it must not be overlooked that they occasionally occur in young children, in boys, and also in men. Why a disturbance of the nervous centres should result in the manifestation of a group of symptoms so closely resembling those of serious joint disease is but one of the many unexplained phases of this disorder. The same may be said of the direction of these symptoms to any particular joint; except that traumatism is in many cases the cause which determines the concentration of the attention upon some one joint.

SYMPTOMS.

These affections may begin gradually or they may be seen following accident. Again they may be the outcome of a protracted convalescence from some joint injury. The symptoms presented are usually much exaggerated and out of proportion to the local signs. There is usually a condition of hyperæsthesia, especially of the skin, which manifests itself most clearly when any manipulation of the affected part is attempted. Although this is a very important factor in the determination of this class of affections, the absence of this hyperæsthesia must not be taken as sufficient evidence to exclude the disease. Another characteristic feature of these disorders is the fact that the objective signs vary from time to time. The stigmata of hysteria accompany many of these cases and when present are of great diagnostic importance.

Organic and functional disease are frequently associated. A young woman with some joint affection of a mild character will sometimes so exaggerate and emphasize her symptoms that the case may appear to be of the most acute sort, but careful examination will perhaps show that the disease is convalescent and that the real condition is very favorable. This can be detected only by a careful examination showing that the muscular stiffness varies much with the attention of the patient and that much pain is attributed to the slightest manipulation which can easily be performed without suffering or muscular spasm when the attention of the patient is diverted, while the muscular rigid-

ity of chronic joint disease is a constant and not a variable resistance to passive manipulation.

Atrophy may be considerable, but it is not more than can be accounted for by disuse.

Distortions of the affected limbs have nothing characteristic about them, except that they may or may not follow the malpositions of the limb which occur in real joint disease. The hysterical knee-joint is often flexed, and the hip may be flexed and perhaps adducted or abducted.

In short, the symptoms of functional joint disease have one distinctive characteristic, they are chiefly subjective, and objective signs of structural trouble are absent or not prominent. A familiarity with the objective signs of disease of the various joints is of course necessary in making the diagnosis of functional troubles, and the foregoing chapters have dealt with those objective signs.

Symptoms often associated with functional disorders are ovarian tenderness and pain, baso-occipital headache, a feeling of suffocation as if a lump were lodged in the throat, and symptoms of this class.

The association of uterine disorders is common, and also another frequent accompaniment is found in the presence of errors of refraction in the eyes.

The surface temperature may be increased, local sweating may occur, and neurologists describe some swelling as an accompaniment of certain cases of functional disorder of the joints.

The correction of all sources of peripheral irritation is of course a matter of much importance.

Spine.

The condition in this location is also described under the names of irritable spine, hysterical spine, spinal irritation, functional affection of the spine, weakness of the spine, neuromimesis, etc.[1] The affection may occur spontaneously or most often as the result of some trauma, either mild or severe. It appears as a sensitive and painful condition of the spine, manifested by sensitiveness most often over the spinous processes of the vertebræ, pain in motion and manipulation; and in most of the cases is associated with a certain amount of general neurasthenia.

Pain and tenderness are frequently found at the base of the neck, between the shoulders, in the lower dorsal region, or at the end of the spine. This pain is usually subacute, it is aggravated by fatigue, and it may be accompanied by much hyperæsthesia, which is usually localized in a comparatively small area where there is a complaint of a burning sensation, while no curvature or projection can be seen on inspec-

[1] Friedberg: Schmidt's Jahrb., 1897.—Bruns' Beitr., xi., 1894.—Willard and Spiller: "Concussion of the Spinal Cord." N. Y. Med. Jour., March 6th, 1897.

tion of the back. In the extreme cases, patients are unable to bear any weight upon the spine in sitting or standing, and they present the symptoms that suggest a hyperæsthesia of the ligaments or of the fasciæ of the back muscles. Ordinarily the patients are able to go about freely, but suffer great pain, especially when their attention is turned to the subject of themselves. In a few instances of the severest sort the back is held stiffly, and any conscious attempt at bending is avoided by the patient; but unconsciously, when the patient's attention is directed in another way, the back will be seen to move with comparative freedom.

A gait which is very similar to that of Pott's disease may be present, and also rigidity of the back in rising or stooping. As in that affection continued standing and walking may cause pain, the patient is very sensitive to any jar and may be relieved from discomfort in the recumbent position.

A careful examination of the patient usually shows that the symptoms of stiffness are more from an apprehension of possible pain of movement than from the unconscious muscular spasm seen in the acute stages of early Pott's disease. Pain on movement, moreover, is usually much greater than is seen in early Pott's disease.

Some deviation from the normal attitude in standing is seen in most cases.[1] This may be a slight lateral deviation of the spine due to a short leg. It may be a rounded back from lack of muscular support, or it may be a position of lordosis and leaning back in an effort to balance. Such patients generally are poorly developed muscularly. Whatever defects exist should be corrected.

Certain cases of backache of this type result from flat-foot or contracted foot. An examination of the feet should always be made.

Sprains of the vertebral column occur at times after falls. Stiffness and pain may reach a considerable degree and render the diagnosis from Pott's disease impossible for a time. In the cervical region wryneck may be present from muscular spasm. The pain may be very severe. This condition of sprain may persist for months, and in neurasthenic persons may merge into the so-called hysterical spine.

Hip.

The symptoms which may present themselves under these conditions at the hip-joint may resemble hip disease in many particulars. There is often complaint of a severe pain in the limb, and any attempt to move the hip elicits expression of pain. There may be an absence of atrophy, and the pain is more likely to be localized at the hip than at the knee, which is the reverse of what happens in true hip disease.

[1] Lovett: "The Neurasthenic Spine." Am. Medicine, November 30th, 1901; N. Y. Med. Journal, May 30th, 1903.

Unconscious movements at the hip-joint may be made more freely than in the painful stages of hip disease. In some instances marked fixation at the hip-joint may constantly be present, but usually the stiffness in examination of the hip is great, but unconscious movements at the hip as in stooping are freer. The stiffness is more the stiffness of apprehension than the limited motion of early disease of the joint. The affection in children is not common, but by no means exceptional. The deformity may be marked and persistent, recurring quickly after reduction.

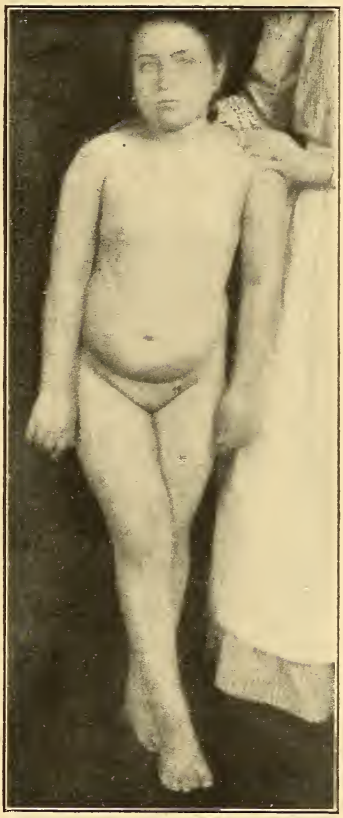


FIG. 409.—Attitude in Walking in a Case of Hysterical Affection of the Joints of the Leg in a Girl of Thirteen.

KNEE.

Functional disease of the knee-joints often simulates either chronic synovitis or ostitis. Pain and tenderness may be present, creaking is noted as an occasional symptom in functional affections, and at times there seems to be present an increase of surface temperature. More commonly the surface temperature of the affected side is reduced. The knee may be flexed, but during sleep that position may be involuntarily abandoned or the leg can be easily straightened, offering but little resistance. Contraction of the knee is often absent. A moderate degree of muscular atrophy is present, especially if, as is usually the case, the knee has been tightly bandaged for some time.

In rare instances some swelling of the periarticular tissues around the knee is observed in this class of cases. The swelling is transitory and does not involve the joint proper.

Nowhere does the diagnosis present greater difficulty than at the knee, where traumatism may loosen the semilunar cartilages to a slight degree or do some similar injury. The diagnosis of functional disease can be made only after the careful exclusion of all organic pathological conditions in both knee and foot. As our knowlege of abnormal conditions in the knee-joint becomes more exact fewer cases are classed as functional.

Ankle.

A functional disturbance in the ankle is not infrequent. It is most commonly met as a result of sprains which have been treated for too long a time by rest and fixation. A condition of muscular weakness, enfeebled circulation, and apprehension at slight pain ensues, and no attempt at the proper means of securing recovery is made, for the reason that the first attempt to use the disabled joint is painful and pain is regarded as a symptom indicative of inflammation.

In functional disease of the ankle an attitude similar to talipes varus or of flat-foot may be seen. The distorted attitude in both the knee and the ankle may be so constantly assumed as to cause a contraction of the hamstrings or tendo Achillis.

At the ankle most cases of functional affection are either the outcome of trauma or are associated with some abnormality of the foot.

The functional affections of the other joints present no points worthy of especial mention.

DIAGNOSIS.

The symptoms are often those of organic joint disease, but the groups of objective physical signs are deficient and inconsistent with one another. The objective signs vary and are not so severe as the symptoms would lead one to expect. Pain is the prominent feature, and muscular rigidity and similar symptoms are of varying severity, according to the concentration of the patient's attention. The presence of superficial hyperæsthesia and of signs characteristic of hysteria with an emotional temperament are facts which should excite attention.

In examining patients in whom a functional affection is suspected, much information can be gained by watching the movements of the patient in getting out of bed, moving in bed, etc. The limbs or back should be bared, and the unaided movements watched. Those suffering from organic disease of the hip or spine show a constant stiffness or attempt to guard or protect the affected limb, which is not displayed to so marked a degree in purely functional affections.

The diagnosis to be of value must in practically all cases be made by a process of exclusion. Again it must be remembered that functional and organic disease may exist in the same joint, that is, legitimate symptoms may be so exaggerated as to constitute a functional affection.

X-ray examinations are of assistance, as they show the absence of organic change in the bone structures which would be present in tuberculous disease of a prolonged or acute course.

PROGNOSIS.

If left to itself, a true functional affection of the spine or joints may improve gradually without special treatment, or it may remain unchanged until the joint function becomes really impaired by the continued inaction. In some cases a sudden and profound mental impression may prove stronger than the idea of local disease and a cure is effected. It is this that the surgeon strives to accomplish in certain cases, it is this that may be brought about by faith cure or charlatanry, and rational treatment of a similar sort can likewise win excellent results if properly carried out.

The age of the patient and the duration of the affection are important in determining the outlook. The older the patient and the longer the course of the disease the less favorable is the prognosis.

The existence of some peripheral source of irritation renders the immediate prognosis perhaps more favorable.

TREATMENT.

In few disorders is a routine treatment of less use than in functional affections of the joints or spine. Especially important, from the outset to the end of the treatment, is an established diagnosis, on which the surgeon can rely. To attempt to follow out a treatment which shall be suitable to either functional or organic disease is fatal to a successful issue. Temporizing on the part of the physician at once makes successful treatment almost impossible. A definite plan of treatment must be formulated and adhered to.

The disorder usually manifests itself as a disability of a limb, the object of treatment being to overcome the disability. Various methods will be needed to effect this.

It is first necessary that the patient be brought into as nearly normal a general condition as possible. The improvement of the local condition is then to be considered and estimated, and finally the patient is to be trained to regain the use of the disabled limb or spine. In cases in which the spine is involved, rest to the back must be secured by recumbency for part of the day. Elaboration of treatment is desirable in many cases and a rigid adherence to a careful and continuous routine of exercises, feeding, and medication must be insisted upon. This class of cases cannot be successfully treated unless due attention is given to regulating and improving diet and general condition, and correcting sleeplessness.

For the treatment of the local condition, the physician has to decide between the necessity of correcting any existing distortion or local improper conditions of circulation or muscular weakness of the limb or

back, and the danger of increasing the expectant attention of the patient by too great attention to the local condition. It is for this reason that counter-irritation and the cautery are to be avoided. It is essential that the local condition should not be made light of by the surgeon, and the reality of the symptoms must be accepted and the disability recognized. A probable hypothesis explaining the condition must be assumed, and treatment based upon this should be carefully and consistently carried out. Any statement that the affection is a trivial nervous disorder or that it can be overcome by exercise of the will is in most cases an error.

An important part of local treatment is the improvement of the circulation in the part affected, and strengthening of the surrounding muscles. This can be done by massage, local hot-air baths, electricity, and gymnastics.

In general the beneficial effect of the local measures adopted must be insisted on, and by a graduated amount of enforced exercise progressively increased, the patient may be surprised into finding herself daily doing more without feeling more pain. Sometimes it may be only practicable to make the patient take two steps a day, but the advance to three and four steps is an important gain. It may be repeated that without a certainty on the physician's part that he is dealing with a functional affection, and without a rigid adherence to his formulated plan of treatment, success is not often to be obtained.

Great benefit can be obtained by graduated exercises in this class of cases. Another useful way of accomplishing this result is by means of mechanical passive and active exercises according to the method introduced by Zander.

Appliances as a rule should be avoided, but in some cases they are temporarily needed to enable the patient to go about more freely when there is marked muscular weakness. They should be discarded as soon as is practicable. In the spine the tempered steel uprights (Chapter XXI., **22**) spoken of in connection with round shoulders are of use temporarily in aiding in the maintenance of the upright position.

In functional affections of the hip, knee, and ankle it is sometimes necessary to employ crutches in order to give locomotion and exercise. Crutches should be used sparingly, and only temporarily, inasmuch as there is danger of the patient becoming habituated to them.

When contractions and malposition of the limbs are present, these should be corrected either by operation or by mechanical means. Operative measures are usually simple, as under an anæsthetic the limb can be pulled readily into normal position, while only in severe cases is tenotomy of the resisting muscles needed. Appliances will probably be required to retain the limb in the corrected position.

Light cases of functional affection of the hip will be best treated at

first by the use of crutches and the elevated shoe to the well foot, aided by gymnastic exercises for the limb of such a character as the patient can endure. The elevated shoe should be lowered and removed gradually, and in the same way crutches should be shortened and replaced by a cane, and finally all support discarded by gradual stages. The use of a hip splint will not often be found advantageous on account of its weight. Traction by weight and pulley is rarely needed, but is sometimes advisable.

Much judgment is required to determine what cases of functional affection of the hip, knee, and ankle joints are to be treated by rest, by protection of the limb, or by use.

Rest in bed is to be avoided unless the patient is in a marked neurasthenic condition needing quiet, but confinement to bed is generally unavoidable during the correction of deformity.

Whatever the methods of treatment to be instituted, it is absolutely essential that the physician should have complete control of the management of the case without interference of friends or relations. Often it is therefore necessary to take the patient away from home for the time being. In many cases the home influence is a most important factor in inducing and keeping up this condition.

It is of importance for the physician to obtain the patient's co-operation in the treatment prescribed. It is a mistake to belittle the symptoms or to treat them as imaginary. They are not only real to the patient, but in fact are probably the result of some unrecognizable central vasomotor disturbance causing functional disability, and not of the patient's fancy. The disability is usually increased by the patient's apprehension or self-will. These are not overcome by contradicting the patient's statements. As the local symptoms of hyperæmia, anæmia, congestion, atrophy, and muscular weakness are diminished by rest, support, careful exercise, application of heat or cold, hot air, vibratory massage, manipulation, or whatever measure may be employed, the use of the limb should be gradually increased with each day's task prescribed. The gradual gain, even if slight, brings encouragement to the patient.

Cases vary in difficulty and often tax the physician's efforts to the utmost in meeting the varying symptoms, but in many instances such efforts are essential as necessary to save the patient from hopeless invalidism.

In cases in which functional symptoms are superadded to an organic lesion, much skill and judgment are required in treatment.

In all these varieties of functional affections, the principle of treatment is the same—temporarily to protect the affected part from strain and painful use, to improve the circulation and increase the muscular strength, and as the condition improves to train the patient to the gradual resumption of the normal use of the limb. A combination of muscular training with mind cure constitutes the treatment.

CHAPTER XVII.

UNILATERAL ATROPHY AND HYPERTROPHY.

Cases of unilateral difference in the growth of the body are of practical interest.

Hunt,[1] of Philadelphia, in 1879, made observations which led him to state that bilateral symmetry as to the length of the lower limbs was exceptional. Since then several observers have corroborated the views of Hunt. Dr. Cox[2] measured the lower limbs in fifty-four healthy persons, and in only six were the limbs of the same length. There was no uniformity with regard to which side was the longer. The variation in length was from one-eighth to seven-eighths of an inch. Wight[3] gives the measurements of sixty persons, and concludes "that the greater number of limbs, comparing the limbs of the same person, show a difference in length. About one person in every five has limbs of the same length." The difference is usually from one-eighth of an inch to an inch. In one case the difference was as great as one and three-eighths inches.

Callender[4] measured forty individuals, and found the limbs of equal length in all but two, in whom the variation was slight. He used a simple tape. All the persons measured happened to be Englishmen. Roberts[5] and Dwight[6] have attempted to settle the question by observation on the bones of skeletons. Roberts found asymmetry the rule in femora and tibiæ in eight skeletons. Dwight reported measurements in eleven skeletons; in five the femora were equal; in one case the difference was three-quarters of an inch. Tibiæ were equal in only two cases. In some cases the longer femora and tibiæ were on the same side, and in some cases on different sides.

Dr. J. Garson,[7] of London, published the results of the measurements of seventy skeletons. The lower limbs were equal, he says, in only ten per cent.

[1] Am. Journal Med. Sciences, January, 1879.

[2] Am. Journal Med. Sciences, April, 1875.

[3] Archives Clin. Surg., vol. i., No. 8, February, 1877.

[4] St. Bartholomew's Hospital Reports, vol. xiv., 1878, p. 187.

[5] Philadelphia Med. Times, August 3d, 1878.

[6] Mass. Med. Soc. Communications, 1878, p. 175.

[7] Journal of Anat. and Phys., vol. xiii., p. 502, 1879. Nature, January 26th, 1884.

Morton [1] has made many measurements and found that among 513 boys 292 presented inequality in the length of the lower limbs varying from one-eighth of an inch to one inch and five-eighths. In 241 there was no appreciable difference in length. In none of these cases had there been previous fracture or any bone or joint disease which might have accounted for the defect. Three of the boys, including those that exhibited the greatest shortening, were aware of the fact that one limb was deficient in length. Burrell [2] reported three cases of marked unilateral atrophy only noticed when the children began to walk, when it became manifest by a limp.

Broca [3] relates the case of a boy of eleven who appeared "as if the two halves of the body were different-sized persons joined together."

Paget [4] found that there is often a difference of volume as marked as is the difference in length, and it is often difficult to say which of the two unequal limbs is the better or the more appropriate to the other parts of the body. In Hartwig's studies of the upper extremity the bones of the right arm were found to be the longest, corresponding with Hyrtl's results. Poncet [5] reported a case of alternate inequality, the right arm and the left leg being better developed.

FIG. 410.—Case of Multiple Plexiform Fibroma. Causing Hypertrophy and much Lengthening of Left Leg. (H L. Burrell.)

The conclusions reached by all have been nearly identical, namely, that throughout the long bones of both extremities there exists often a certain amount of asymmetry in regard to length.

The very important theoretical and practical bearing of this is easily seen. The relation that short limbs may bear to cases of lateral curvature [6] has been discussed.

[1] "Asymmetry of the Lower Limbs," etc. Phila. Med. Times, July 10th, 1886.
[2] Boston Med. and Surg. Journal, vol. cvi., p. 462.
[3] Canstatt's Jahresbericht, 1859, vol. iv., p. 6.
[4] Am. Journal Med. Sciences, January, 1886.
[5] Lyon Médical, January 29th, 1888.
[6] Revue de Chirurgie, April 10th, 1888.

The progressive facial hemiatrophy is of interest from an etiological standpoint.

The *etiology* of these different forms of atrophy or hypertrophy is obscure. In the cases of injury to the joints Nicoladoni suggested a premature synostosis of the epiphyseal cartilages. The facial hemiatrophy is thought to be a trophic neurosis of certain nerve ganglia or nerves—or a simple vascular disturbance of the part has been suggested as a possible cause.

It is probable that certain of these cases are the result of a slight former hemiplegia, which has manifested itself chiefly in retarding the growth of the affected side without any distinct loss of motor power.

Symptoms and Treatment.—Long-continued slight and oftentimes severe backaches, with lumbar and pelvic pain, involving the distribution of the sciatic nerve, are often due to asymmetry of the lower limbs. Such symptoms are at times at once relieved upon correcting the asymmetry by increasing the height of the shoe of the shortened limb. A person in previous good health may from some depressing physical condition begin to have the above symptoms of pain localized as stated, and upon examination unequal limbs will be found in very many cases.

Morton said that United States pension-examining surgeons stated that many applications for pension have been made for disabilities described as lumbago, supposed to have been caused by exposure or by injuries contracted during the war for the Union. In nearly all such cases an examination revealed a previously unrecognized asymmetry, and the symptoms were probably induced by this defect in development.

Symptoms of inequality of the lower limbs may simulate coxalgia. In such cases the legs should, of course, be measured. Children complaining of backache, or so-called growing pains, should be carefully examined for any such anatomical defects.

The medico-legal bearing of the fact of asymmetry has been called attention to by Hunt in the paper already referred to.

Hypertrophy of the limbs may occur either from dilatation of the vessels (as in angioma), from disease of the lymphatics, and from congenital anomaly.[1]

[1] "Clinical Report Children's Hospital Service." Boston Med. and Surg. Journ., cxliv., 14, p. 329.

CHAPTER XVIII.

CONGENITAL DISLOCATIONS.

Congenital dislocation of the hip.—Frequency and occurrence.—Etiology.—Pathology. — Symptoms. — Diagnosis. — Differential diagnosis. — Prognosis. — Treatment.—(Reduction with aid of mechanical force.—Tenotomy, fasciotomy. —After-treatment. — Relapses —Osteotomy.—Treatment of older and adult cases.—Summary.)—Congenital dislocation of other joints —Knee.—Patella. —Congenital absence of the patella.—Ankle.—Shoulder.—Elbow. — Wrist. Cubitus valgus, cubitus varus. —Spontaneous subluxation of the wrist.

CONGENITAL DISLOCATION OF THE HIP.

Congenital dislocation of the hip is neither a common affection nor one of very great rarity. Among 6,969 orthopedic patients applying at the out-patient department of the Children's Hospital, there were 152 cases of congenital dislocation of one or both hips. Chaussier, in 23,293 infants born at the Maternité, found only 1 case of congenital luxation. But it is probable that it occurs in reality much oftener than it is recognized clinically. Parise dissected the hip-joints of all children dying while he was interne at the Hôpital des Enfants trouvés, and in 332 he found congenital dislocation of one or both hips in 3.

The distribution of the affection between the sexes and in one or both joints can be seen from the following tabulation of collected cases:

	Number.	Boys.	Girls.	Single Right.	Single Left.	Double.
Drachmann	77	10	67	24	24	29
Pravaz	107	11	96	27	29	51
Krönlein	90	14	76	32	22	31
N. Y. Orth. Hosp. and Disp.	25	2	23	5	10	5
Boston Children's Hospital	24	0	24	7	11	6
Prahl	18	3	15	0	0	0
	341	40	301	95	96	122

The affection is much more common in girls than in boys, 301 of these 341 cases (88 per cent) having been observed in females. No satisfactory explanation has been advanced to account for this preponderance in girls.

Etiology.—The etiology of the affection is not known. True congenital dislocation without doubt is an affection of uterine life, congenital dislocations having been found in the fœtus. It would seem also

that it is not an arrest of development like harelip, but like congenital club-foot rather a perversion of it, a malposition of bones with the resulting structural changes of the soft parts. Violence at birth alone, is not considered the cause of true congenital dislocation. The theory that the deformity is due to intra-uterine pressure at a period of fœtal development is held by many.[1] This theory, however, does not explain the fact that the affection is much more frequent among girls than among boys. The lack of complete development in the acetabulum

FIG. 411.—Lordosis and Prominence of Trochanters in Congenital Dislocation of the Hip. (J. S. Stone.)

FIG. 412.—Unilateral Dislocation of the Hip. (Fiske Prize Fund Essay.)

described by many writers will be found after thorough examination of pathological specimens to be explained by the malposition of the parts during a portion of the period of fœtal life rather than by a structural arrest of development.

[1] A specimen was described by Mr. Jackson Clark in which in uterine life the thighs were flexed for so long a period without extension as to cause firm contraction of the anterior portion of the capsule. Later extension of the limb, possibly from an increase of the amniotic fluid or from any cause, would, in a shallow acetabulum, cause dislocation of the hip (Brit. Ortho. Trans., vol. i.).

There is, undoubtedly, a tendency to heredity in congenital hip dislocation. Dupuytren relates the case of three families in which the affection was present in several members, and cases are related by Bouvier,[1] Verneuil, Stadfeldt, Caswell, and Volkmann. It has been observed in two instances at the clinic of the Children's Hospital. In each instance two sisters were similarly affected.

Pathology.—The changes in the anatomical structures seen in congenital dislocation are found in the capsule, in the muscles, and in the

FIG. 413.—Prominence of Trochanters in Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

FIG. 414.—Lordosis in Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

bones. The changes in the capsule are such as would naturally follow a prenatal dislocation before the joint structures were formed. Normally the capsule passes from the rim of the acetabulum to the neck of the femur, the head being placed well in the socket. In congenital dislocation, when the head lies out of the socket and above the acetabulum, the capsule is stretched. Furthermore, the weight of the body, as soon as the individual walks, rests not on the head of the femur

[1] Bouvier: "Leç. Clin. sur les Mal. chron. de l'App. locomoteur."

placed under the acetabulum, but falls upon the capsule, which stretches like a strap from the acetabulum to the trochanter, and this capsule necessarily becomes thickened. As it is stretched across the acetabulum it becomes adherent at the rim and to a portion of the ilium, so that the acetabulum seems obliterated, being covered by thick, strong, fibrous tissue, reaching from rim to rim. This portion of the capsule is entirely shut off by adhesion from that which surrounds the head, save for a small opening at the upper portion of the rim. This opening may be, and usually is, smaller than the head, and not easily stretched, as the tissues lose their elasticity owing to the fibrous bands which form from the use of the capsule as a weight-bearing structure.

FIG. 415.—Broadening of Perineum in Double Congenital Dislocation of the Hip. (Fiske Prize Fund Essay.)

The muscles are changed in consequence of the altered position of the head. Some of the muscles are shortened, others are lengthened. The muscles which are shortened are the adductor group, the psoas and iliacus, and the muscles reaching from the tuberosity of the ischium to the leg, *i.e.*, the hamstring muscles. The glutæi muscles are not shortened, and the group of muscles which pass from the pelvis to the greater trochanter, the obturators, gemelli, etc., are lengthened. The capsular and periarticular ligaments adapt themselves to the position of the deformity, and those which are attached to the lesser trochanter are particularly strong and firm to prevent the pushing of the head upward, when weight falls upon the leg. It is these tissues which oppose any attempt at reduction, and unless they are stretched or divided the deformity cannot be corrected. The alteration in the bone consists of a flattening or alteration of the shape of the head, a twist of the neck, the consequence of malposition of the head, and in the shape of the acetabulum, which is sometimes triangular in shape and shallow.

Three varieties of congenital dislocation, classified according to the position of the head, are mentioned, viz., backward, upward, or forward. The backward or dorsal is much the most common.

If the point of suspension is directly over the proper place for the acetabulum, the patient's pelvis is hung in a comparatively normal

plane, but if much behind it the pelvis is tilted and severe lordosis results, the latter being the more common condition.[1]

Symptoms.—The deformity usually attracts no attention until the child learns to walk at the age of two or even three years. Then it is noticed to stand ordinarily with its back very much arched and to waddle most markedly when walking is well begun. This waddle is characteristic and very marked. When the dislocation is only unilateral, the waddle becomes an exaggerated limp; in stepping on that leg the child leans to the affected side, and the leg seems to have grown suddenly shorter; the child recovers itself at once and goes on with this sudden giving way whenever the affected leg is stepped upon. In

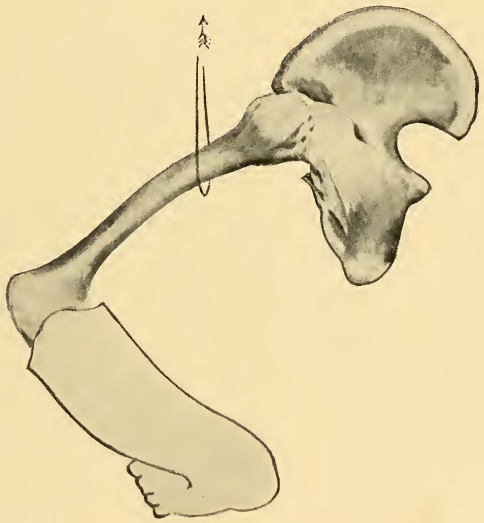


FIG. 416.—Congenital Dislocation of the Hip in Full-term Fœtus. (Warren Museum.)

double dislocation, in young children, the prominence of the trochanters is not marked enough to attract attention; in older persons, however, the prominence of the trochanters and buttocks is most noticeable. There is no complaint of pain by children suffering from this affection.

Diagnosis.—The diagnosis rests chiefly on one point, the position of the trochanters above Nélaton's line, which is drawn from the anterior superior spine of the ilium to the tuberosity of the ischium. In small, plump children it is sometimes difficult to determine accurately whether the trochanter is on the line or very slightly above it. The displacement of the trochanter upward varies from half an inch to one

[1] The pathological condition of congenital dislocation has been recently most thoroughly investigated by Dr. E. H. Nichols, of Boston, to whom the writers are indebted for information on the subject (Trans. Am. Orth. Assn., 1896).

or two inches, according to the severity of the case, but on careful palpation the head of the femur can often be felt on deep pressure if the limb is rotated, as moving in an abnormal excursion outside of the acetabulum.

As the child lies on its back, the perineum is noticed to be unusually broad in double dislocation, the legs will perhaps be everted, perhaps in normal position, and on manipulating them they will be found in young children to be unusually movable, especially in the direction of eversion.

On pulling the leg with gentle force the trochanter will be felt

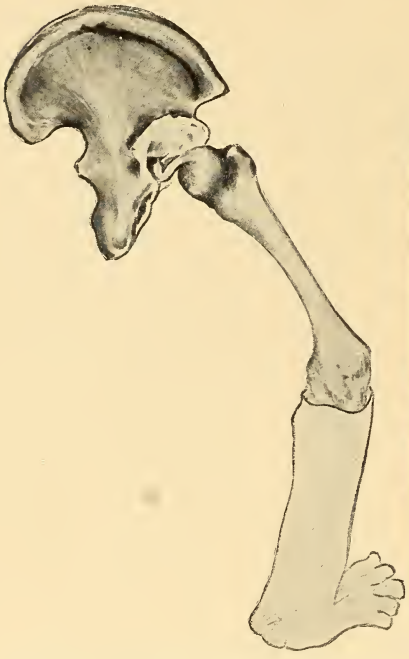


FIG. 417.—Congenital Dislocation of the Hip in Full-term Fœtus. Capsule removed. (Warren Museum.)

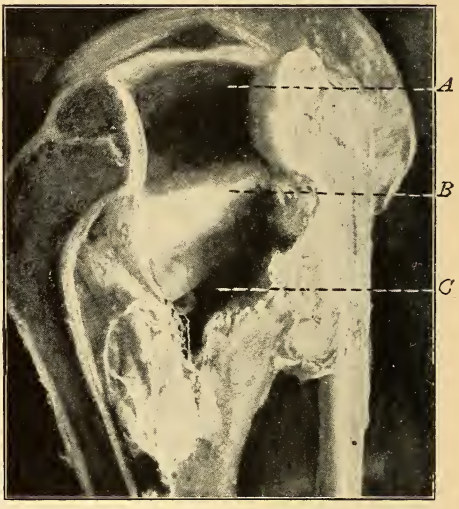


FIG. 418.—Specimen of Congenital Dislocation of Hip. *A*, Capsule stretched around distorted head; *B*, portion of contracted capsule; *C*, capsule leading to acetabulum.

drawn down, if the other hand is placed upon it, and to slip back when the leg is released, and a measurement will show that the leg has been lengthened temporarily by the traction force.

The muscles, although not normally developed, are not paralyzed, and the children are ordinarily healthy ones. In unilateral dislocation the leg of the affected side is slightly smaller than the other.

In larger children and adults the conformation and outline of the hips are so distinctive that the diagnosis may be made almost at a glance; but in young children palpation or a skiagraphic examination is often necessary.

Trendelenburg has called attention to an important diagnostic symptom. When a normal child stands upon either limb and flexes the other at the knee and thigh, the opposite buttock will be seen not to drop. In the case of congenital dislocation of the hip, however, the opposite buttock will be found to drop to a noticeable degree if the patient takes this attitude. This is to be explained by the fact that in congenital dislocation of the hip, owing to the fact that the head of the femur is not in the socket, the muscles from the great trochanter and the pelvis (which serve to keep the pelvis level) when supported on one side have no purchase and are therefore inefficient.

In small children with fat buttocks it is sometimes difficult to find

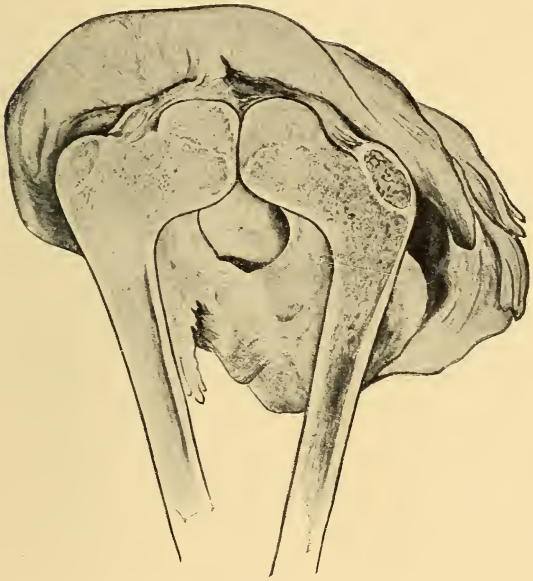


FIG. 419.—Congenital Dislocation, Child of Ten. Femur sawn and sides reflected, showing dislocated position of the femoral head, the capsular pouch, the capsular hymen in front of the acetabulum, the acetabular cavity, and capsular constriction at the mouth. (Warren Museum.)

FIG. 420.—Congenital Dislocation of the Hip. Cross section of femur and acetabulum (femur turned back), showing capsular constriction at mouth of acetabulum. Child three years old. (Warren Museum.)

with certainty the dislocated head. The diagnosis is aided by remembering that when the head of the femur is in the acetabulum, rotation takes place with the acetabulum as the centre, and the neck as the radius of the arc of motion; when the head is out of the acetabulum, the trochanter is the centre of motion, and the looser head describes the arc.

A skiagraphic picture is of great value in diagnosis, and if accurate is conclusive.

Differential Diagnosis.—The following affections may be confounded

with congenital dislocation of the hip in smaller children: coxa vara, distortion following infantile paralysis, separation of the epiphysis, deformity following early arthritis of infancy, traumatic dislocations, and the deformities of hip disease.

In all these affections, with the exception of the first, viz., coxa vara, there should be a history of previous injury or illness; and in all, with the exception of coxa vara and infantile paralysis, the freedom of motion of the femur seen in early congenital dislocation is not found.

Coxa vara, or the distortion of the neck of the femur, which shortens the limb and raises the trochanter above Nélaton's line, may be

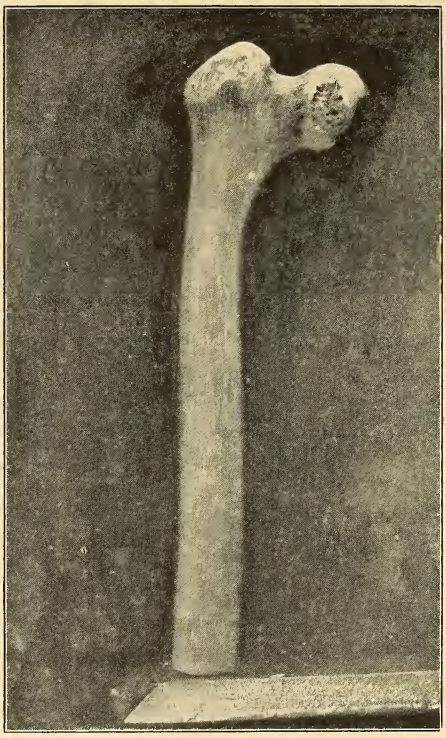


FIG. 421.—Femur in Congenital Dislocation, Showing Alteration in Angle of Neck.

confounded with congenital dislocation. The mistake can be avoided if the fact is borne in mind that in coxa vara the head is in its normal socket, while in congenital dislocation the head is to be felt outside of the acetabulum. Coxa vara is only very exceptionally noticed as early as three years of age.

The affection of congenital dislocation is occasionally regarded as a disease of the spine, as marked lordosis is always present, and in many instances spinal corsets have been applied with the idea that this is the chief source of the trouble.

Prognosis.—The disability caused by this affection in childhood is slight. The limp is noticeable, and, in double congenital dislocation, may be distressing. As the patient becomes older and the weight increases, some annoyance may be caused in adolescence; but this ordinarily is not great until middle life or old age. In single dislocation the defect in adults may be only an inability to engage in active occupation, accompanied by occasional attacks of severe muscular pain, with muscular cramps. These attacks subside under rest, but if the patient becomes heavier or feeble they may necessitate the use of crutches and cause severe disability. When the dislocation is on the dorsum the disability is greater than when it is anterior or above the

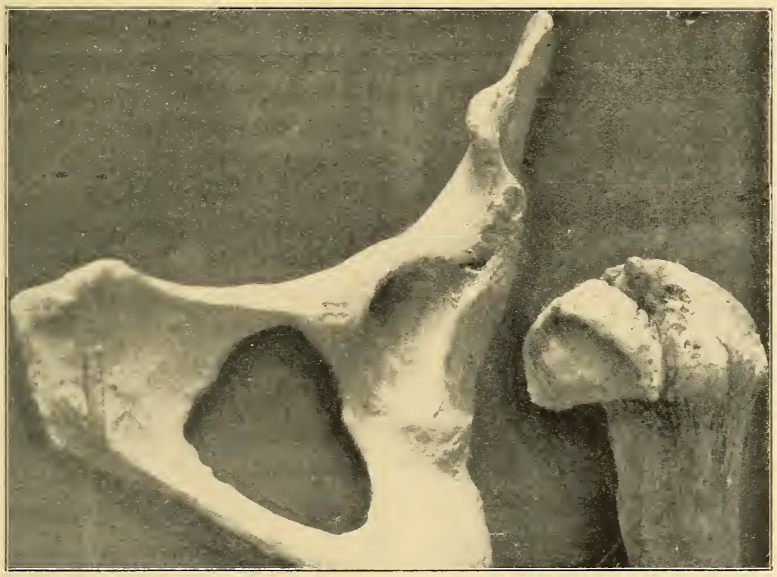


FIG. 422.—Old Congenital Dislocation of Hip with Alteration of Neck of Femur to Shape of Acetabulum. (Warren Museum.)

acetabulum. Muscular patients suffer less than those with feeble muscles. In double dislocation the trouble is increased.

No strong acetabulum develops around the dislocated head, and with the body suspended from the femurs by a loose capsular ligament, the patient goes through life walking with discomfort and effort at each step, always preserving that most characteristic swaying from side to side.

It may be said that in general the tendency of these cases when untreated is to remain stationary or to grow somewhat worse. The pelvis, although altered in shape, does not appear to be changed in such a way as to interfere with childbirth.

The prognosis in cases which are treated will be considered under that head.

Treatment.—Attempts at reduction without operation have proved unsuccessful, although cases by Pravaz, Buckminster Brown, and Adams were thoroughly treated by traction for a long period and apparently benefited at first. The ultimate results were, however, entirely unsatisfactory, and the method cannot be recommended.

Operative measures when first attempted without a thorough

FIG. 423.—Congenital Dislocation, Showing Dropping of Pelvis when Patient Stands on the Affected Limb.

FIG. 424.—Coxa Vara, Showing Elevation of Pelvis when Patient Stands on Affected Limb.

knowledge of the pathological conditions also failed, but through the valuable work of Hoffa and Lorenz successful operative methods have been developed and a reasonable and increasing percentage of success is obtained in suitable cases.

Mechanical treatment and the treatment by traction continued for a long period, advocated by Pravaz, Adams, and Buckminster Brown, have not given results which were permanently successful.

The operative methods may be termed:

1. Reduction by open incision.
2. Reduction by forcible manipulation.

Reduction by Open Incision.

To Hoffa belongs the credit of having first presented to the profession an operative method of value. This has been modified by Lorenz and himself and may be described as follows:

The patient is to be placed upon the back with the limbs slightly

Fig. 425.—Double Congenital Dislocation Unreduced.

abducted and rotated outward. The incision is made in a line drawn from in front of the anterior superior spine, obliquely downward and

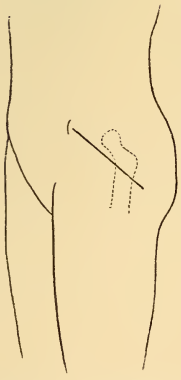


Fig. 426.—Line of Incision for Operative Reduction.

Fig. 427.—Second Step.

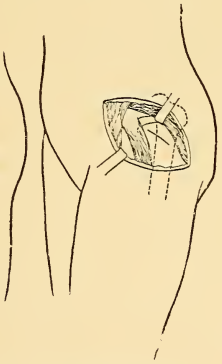


Fig. 428.—Third Step.

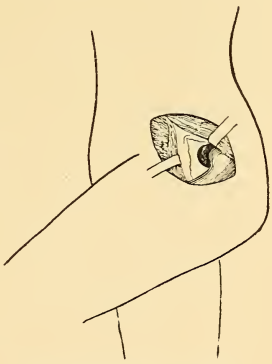


Fig. 429.—Fourth Step.

backward, crossing the femur a short distance below the top of the trochanter. The incision should be along the outer edge of the tensor vaginæ femoris, between this and the anterior border of the glutæus

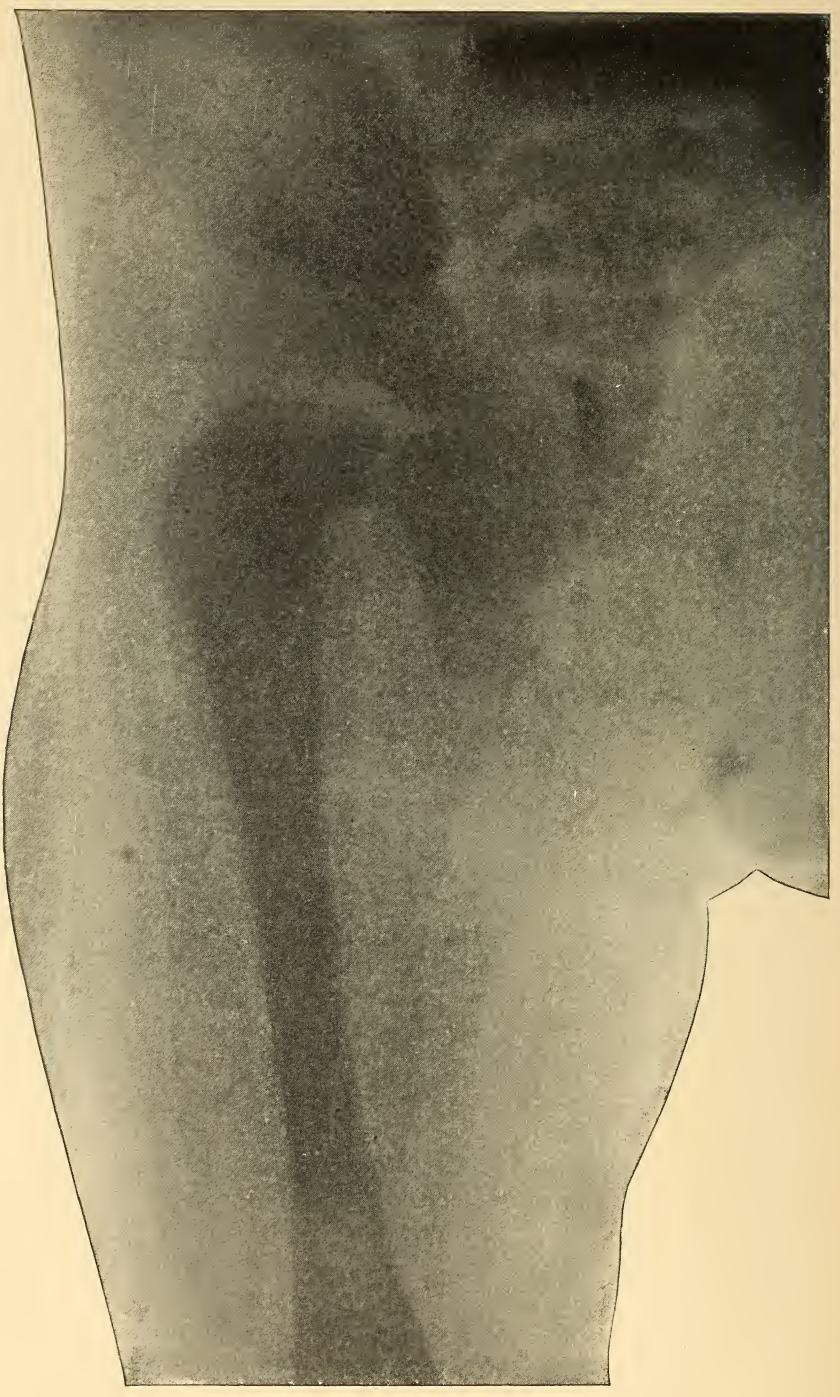


FIG. 430.—Congenital Dislocation Reduced.

medius. The incision should pass well below the top of the femur, and should cross it slightly above the level of the trochanter minor. The tensor vaginæ femoris is retracted and the fascia lata divided by a straight incision, and, if necessary, by an additional cross incision. The glutæus is also retracted, and beneath the tensor muscle the rectus femoris will be found, with a reflected tendon passing outward, to be attached to the ilium above the acetabulum. If the muscular tissues are well retracted the capsule will be uncovered and can be split. This

FIG. 431.—Congenital Dislocation. Reduction by incision. Osteotomy of shaft to correct twist of neck.

should be done by an incision in the direction of the original skin incision, and should be free enough to expose the whole head and neck as far as the trochanteric line, and, if necessary, a cross incision is made. An assistant should flex the thigh to a right angle to the trunk, and the attachments of the capsule to the neck and the trochanteric line, including the lesser trochanter, should be thoroughly freed both on the anterior and posterior surface of the neck to such an extent that the surgeon can pass his finger completely around the neck. The head can then be thrown out, the ligamentum teres having been divided, if pres-

ent. The head of the femur can then be pulled aside and a clear view of the capsule covering the acetabulum, as well as the acetabulum, can be had. If the capsule is constricted above the acetabulum it can be cut with a herniotome or stretched with a dilator or enlarged with a curette. It is important that the bony edge overhanging the acetabulum should project sufficiently to furnish a firm socket after the head is reduced. It is sometimes difficult, if the tissues are imperfectly divided, to find the socket, for the reason that a portion of the capsule lies flat across the socket and is adherent to the edges, the surgeon feeling only the upper edge and a mass of connective tissue; but when this difficulty is met it is necessary to enlarge the incision, as it is essential that the head be placed well in the socket. It is not infrequently necessary to

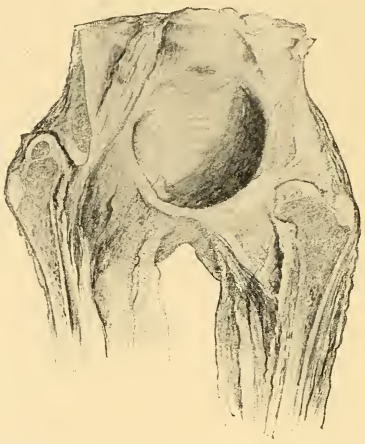


FIG. 432.—Double Congenital Dislocation of the Hip. Reduction on left side by open incision. Relapse on right side after attempted manipulative reduction. Capsular constriction at mouth of right acetabulum. Death six months after operation.

deepen the acetabulum by means of a curette or gouge. This is necessary if the acetabulum is abnormally shallow.

It is sometimes necessary, if the head of the femur is conical in shape, to remove a portion; but if the cartilage on the acetabulum is removed and the head of the femur freed from its cartilage, ankylosis is liable to result. It is particularly necessary that the capsule should not be folded in attempted reduction in such a way as to prevent the free entrance of the head into the acetabulum, and it is especially important that the connection between the acetabulum and the femur at the trochanteric line and lesser trochanter should not be so firm as to prevent the easy reduction of the head into the socket. When it is found that the head when reduced into the socket will not remain there if the leg is adducted or extended, some remaining fibres of the capsular attachments on the anterior surface, passing from the ilium to the lesser

trochanter and its adjacent parts, will be found to exist. After the acetabulum has been deepened sufficiently, the reduction of the dislocation should be performed.

After the reduction the redundant capsule can be closed, with a wick for drainage, or packed, according to the judgment of the surgeon.

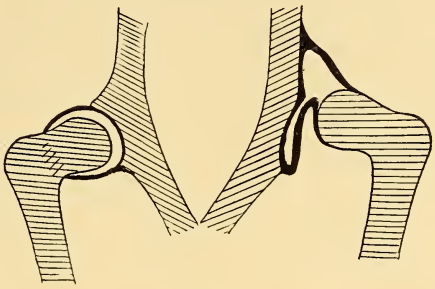


FIG. 433.—Diagram of Section of Capsule in Normal and in Congenitally Dislocated Hip.

Drainage is to be regarded as of importance, as the cavity is a deep one and may be shut off. Furthermore, in this region the danger of infection from urine, in small children, is to be considered. The experience at the Boston Children's Hospital has, however, been in favor of clos-

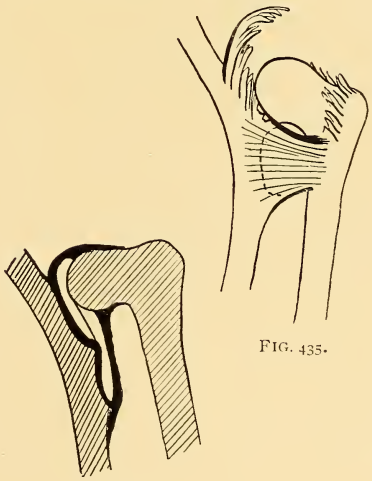


FIG. 435.

FIG. 434.

FIGS. 434 and 435.—Diagram Showing Difficulties in Reduction. 1, In the capsule covering the acetabulum; 2, in the shortened capsule between the acetabular rim and the lesser trochanter.

ing the wound at the time of operation, leaving only a gutta-percha tissue wick, to be removed in a short time. When absolute confidence can be placed in thorough asepsis, closing the wound in this way at the time of operation saves for the patient a long period of wound-

healing. The limb should be flexed by means of a plaster-of-Paris spica reaching from the thorax down to the foot, holding the limb in a strongly abducted position. The position of the limb can be gradually brought to normal by later application of plaster-of-Paris bandages.

Reduction by Forcible Manipulation.

This method, requiring necessarily the employment of an anæsthetic, was first attempted by Post, of Boston, without a permanent successful result. Paci, at the International Medical Congress in Rome, showed several cases successfully treated by a manipulative method of reduction under an anæsthetic. This has been elaborated by Lorenz, of Vienna, who has extensively demonstrated the details of the method.

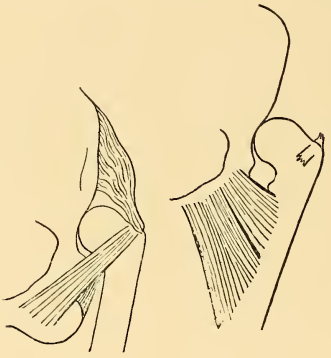


Fig. 436. Fig. 437.

Figs. 436 and 437.—Diagram Showing Pelvi-trochanteric and Pelvic Muscles in Congenital Dislocation of Hip.

The method of manipulative reduction is based on the fact that in many instances the head can be placed in the acetabulum after all the obstructions caused by the contracted soft parts are overcome by stretching, and that this can be done satisfactorily by using the femur as a lever.

Complete anæsthesia is necessary. The child's ankle is grasped firmly and a strong pull exerted, counter-pull being furnished by an assistant who presses upon the perineum or, in the more resistant cases, pulls upon a folded sheet, one end of which is passed under the perineum. The limb should be rotated forcibly to both the outer and inner side, and then forcibly abducted both with the knee flexed and straight.

It is essential that the adductor group of muscles should be overstretched or torn, and this can be aided by forcible massaging or by striking with the hand the belly of the long adductor. After the limb has been brought to a right angle with the axis of the trunk, and in some instances twenty degrees beyond, the knee being straight, it should be again brought in a line of the axis of the trunk and then forced upward with the knee straight, until the thorax is touched by the

front of the thigh, thus stretching the hamstring muscles. The child should then be turned upon its face and forcible hyperextension used, both with the leg abducted and straight. The child is then placed upon its back and reduction attempted, the surgeon holding the patient's limb just below the knee, which is flexed with one hand, the other hand being placed upon the pelvis, the palm pressing on the crest of the ilium and the thumb passing behind and beneath the trochanter. The thigh is then flexed and abducted, and with the limb in this position the operator should press the head of the femur downward with the exer-

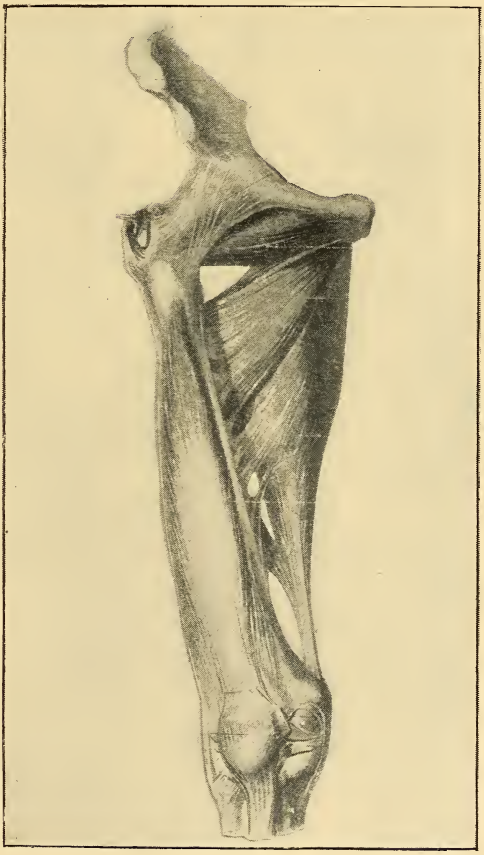


FIG. 438.—Dissection Showing Tendinous Insertion of the Lower End of the Adductor Magnus.

cise of strong force, to stretch the lower border of the capsule. The child is then turned upon its face and hyperextension exerted, both with the limb abducted and in a line with the body.

The child is then placed upon its back and an attempt at reduction made. If the tissues have been sufficiently stretched by the above-

mentioned manœuvres, the reduction can be easily made. The surgeon holds the patient's limb just below the knee with the hand, abducts the limb strongly, flexing it at the knee. The other hand is placed upon the pelvis, the palm of the hand resting on the anterior spine, and the thumb being placed under the trochanter, while an assistant steadies the pelvis by pressing upon the opposite side. The patient's knee is pressed downward from the plane of the operating table, while the trochanter is pressed upward and slightly forward. In successful cases the head will be felt to slip into the acetabulum with a sudden movement characteristic of the reduction of a dislocation.

It is often necessary to give slight rotary motion to the limb and slight manipulation is often necessary. The surgeon can use the head

FIG. 439.—Manipulative Reduction in Congenital Dislocation of the Hip. Traction and reduction.

of the femur to determine the size and depth of the acetabulum, and the firmness with which it is held in the acetabulum is also to be noted.

In the more resistant cases a padded, wedge-shaped block placed behind the trochanter will be of assistance, serving to push the trochanter and head of the femur forward, while the patient's knee is pressed downward. When the head of the femur is well in the acetabulum it can be felt on careful palpation, lying under the point of intersection of a line following the femoral artery, with a line crossing the pelvis at a level with the top of the symphysis pubis. A tightening of the hamstrings will usually be observed on reduction of the hip. After the reduction has been made, the limb should be carefully brought into a straight position, *i.e.*, parallel with the long axis of the trunk. If dislocation occurs during this manipulation the tissues must be stretched still further and the head again placed in the acetabulum.

Reduction with the Aid of Mechanical Force.

In the younger cases little difficulty will be encountered in stretching the shortened muscles by the use of manipulation as described, but in older cases much force is necessary, which involves danger of fracture of the femur or pelvis, both of which accidents have occurred in manipu-

Fig. 440.—Manipulative Reduction. Forced abduction stretching the adductors with blows upon the adductor attachment.

lative reduction. A difficulty encountered where manual force is employed is in holding the pelvis. This is essential to the accurate employment of force, and the accurate employment of force is of the greatest importance if much force is to be used.

It is for this reason that mechanical aids have been advised in the reduction of congenitally dislocated hips. One of the most efficient of apparatus for the purpose is an appliance devised by Mr. Ralph W. Bartlett, of Boston.[1] It consists of a perineal resistance plate, traction

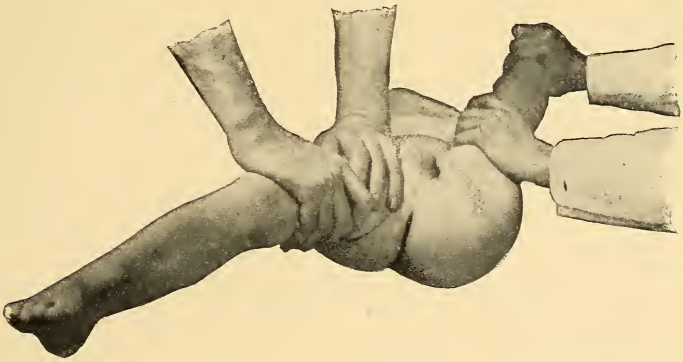


Fig. 441.—Manipulative Reduction. Forced flexion with leg straight at knee.

rods, and cylinders, which press on the pelvis at and above the trochanters. The traction rods are attached to the cylinders, and moving about each cylinder is a metal collar controlled by a handle. The collar is armed with a plate which can be made to press the trochanter down-

[1] Jour. of Med. Research, new series, vol. v., December, 1903, pp. 440–448.

ward and forward. The cylinder is pivoted upon an eccentric pin, and when moved by a wrench can be made to increase the pressure of the trochanteric plate.

The patient is placed in the apparatus with the perineum pressing on the perineal plate; the trochanteric cylinders are adjusted to press

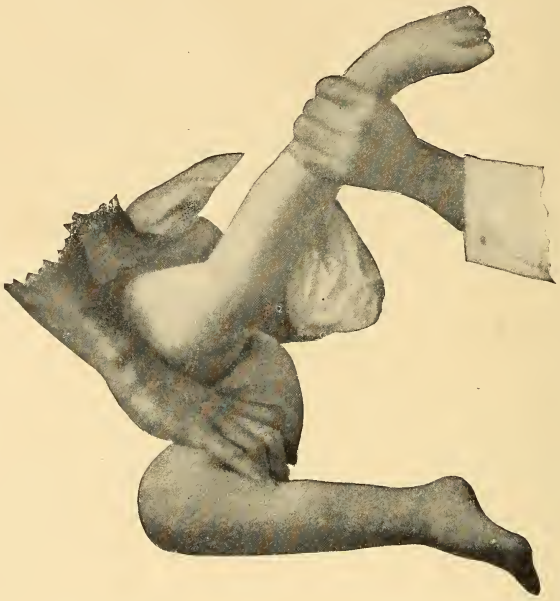


FIG. 442.—Manipulative Reduction. Hyperextension.

upon and above the trochanters. The patient's ankles, protected by saddlers' felt and leather, are connected to the windlass at the bottom of the traction rods by means of rawhide straps. With the aid of this

FIG. 443.—Manipulative Reduction. Head of femur pressed into acetabulum by manipulation after all contracted tissues are relaxed by overstretching.

mechanism, traction to any extent can be applied, and in connection with it a strong abducting force, with, in addition, a force which will press the trochanter and head downward when the limb is strongly

abducted. The danger of fracture is diminished, as the replacing force is applied when the head is pulled away from the pelvis.

This appliance has been used at the Boston Children's Hospital for the past two years, after careful experiments upon cadavers, and its efficiency proved in a series of thirty cases, some of these of the more resistant type.

The Bartlett machine is to be regarded as a stretching appliance rendering the manipulative reduction easy after the thorough stretching. In some instances a reduction takes place by the aid of the apparatus alone, rotation of the stretched limb being sufficient to lift the femoral head into the acetabulum. In the more difficult cases, however, the child is to be removed from the stretching apparatus and the ordinary manipulations applied.

FIG. 444.—Plaster Fixation after Reduction of a Congenitally Dislocated Hip. Foot raised to improve locomotion.

TENOTOMY, FASCIOTOMY.—The most important tissues other than the capsule which need to be stretched to enable the surgeon to replace a congenitally dislocated femoral head are the adductor group of muscles, the hamstrings, and the fascia lata, including the ilio-femoral band.

The adductor group of muscles can be stretched with comparative ease, with the exception of the fibres of the adductor magnus, which pass from the tuberosity of the ischium and are collected into a tendon of considerable size, which is inserted in a tubercle above the internal condyle of the femur. These fibres are not of importance in limiting the adduction of the limb and are not stretched by forcible abduction. They do serve, however, as a check to lengthening the limb, and in resistant cases offer the strongest resistance to a traction force needed to pull the head of the femur down to the level of the acetabulum. This resistance can be readily overcome by tenotomy of the tendon at the lower end of the adductor magnus. If a small incision is made on the inner side of the internal condyle of the femur, this tendon can be easily found, a director or hook passed underneath it, and a division of the tendon made without difficulty by a scalpel or scissors. It will be found that no other tissues in the adductor group will

offer serious obstacle to the stretching movements preliminary to reduction.

The ilio-tibial band which offers the strongest resistance to elongation of the limb can be readily divided by a tenotome inserted beneath the skin a short distance above the external condyle. The band is from an inch to two inches in width, and can be easily felt beneath the skin on the outer side of the leg when traction is applied to the ankle.

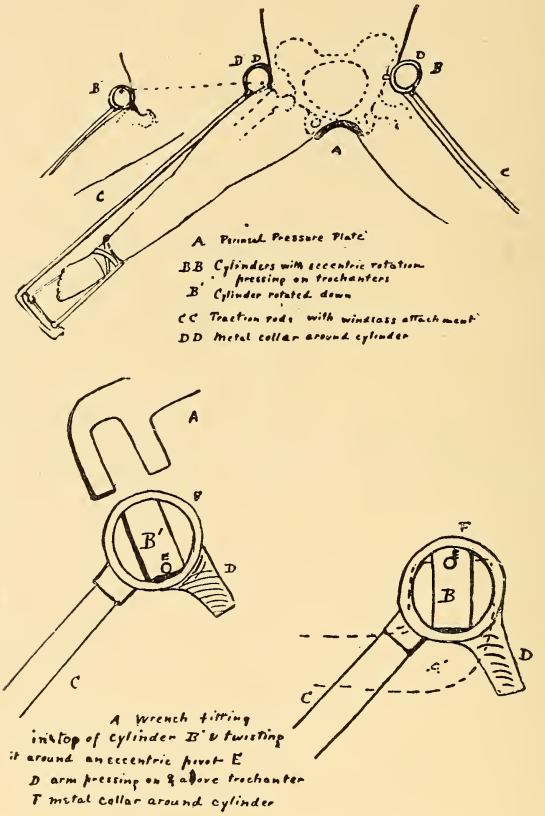


FIG. 445.—Details of Bartlett Machine, Showing Effect of Eccentric Movement.

In double congenital dislocation of the hip where lordosis is well developed, the anterior portion of the fascia lata offers an obstacle when traction is applied, this force acting rather to increase the lordosis than to pull down the femoral head. This obstacle can be overcome by dividing the fascia near its attachment to the anterior superior spine. If a small incision is made through the skin a short distance below the anterior superior spine and the skin is retracted the fascia can be divided freely.

Although the hamstring muscles offer considerable resistance to

pulling down the dislocated femoral head, tenotomy of their tendons, though easily performed, is rarely necessary, for the reason that the resistance of these muscles can be readily eliminated by flexing the thigh and knee. After the reduction it is important to stretch these muscles that the limb should be placed in a normal position without dislocating the head. This can usually be accomplished by forcible straightening of the limb with the knee extended after the head has been reduced. The above-mentioned procedures need not be considered except in the more resistant cases. No other resistant tissues are of importance, with the exception of the capsule.

These measures are usually not needed, as the tissues can be stretched without resort to tenotomy in ordinary cases.

Accidents.—The method of reduction of congenital femoral dislocation by manipulation is not without danger and requires the exercise of considerable judgment. Fracture of the femoral head, fracture of the

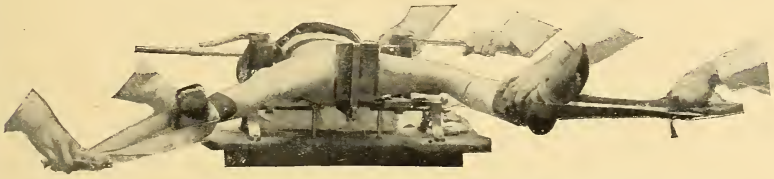


FIG. 446.—Bartlett Machine. Reduction of congenital dislocation of the hip.

pelvis, death from shock, rupture of the femoral artery, temporary and permanent paralyses have all followed the injudicious use of force in correcting this deformity. These accidents can be avoided if the method is limited to the less severe cases.

Slight paralyses not infrequently follow manipulative reduction, but pass away without treatment in a short time.

From the experience at the Boston Children's Hospital it would appear that the danger of injury in forcible reduction is diminished by the employment of a mechanical appliance similar to the Bartlett machine. Great care, however, and judgment are necessary in the use of this as of all powerful aids.

AFTER-TREATMENT.—After the hip has been placed in the acetabulum, it is necessary that it should be held in the socket until the capsular tissues are sufficiently strong to prevent a relapse.

The child, while still under the anæsthetic, is placed upon a pelvic support and a firm plaster bandage applied to the thigh and pelvis, protected by stockinet, felt, and cotton. The thigh should be flexed and abducted so that it is held at a right angle with the long axis of the body and with the inner condyle on the same plane as the symphysis pubis or a little lower. In this position the muscles are at a disadvantage in exerting a dislocating force; the neck of the femur points for-

ward and the head is pushed forward. This position renders difficult a relapse in the direction of a backward dislocation and favors the cicatrization of the posterior capsular tissues. It favors anterior displacement, however, and the contraction of the tissues which check the bringing of the limb to the normal straight position.

The position should be changed as soon as danger of a relapse in a backward direction is past. If it is necessary to retain the limb in the

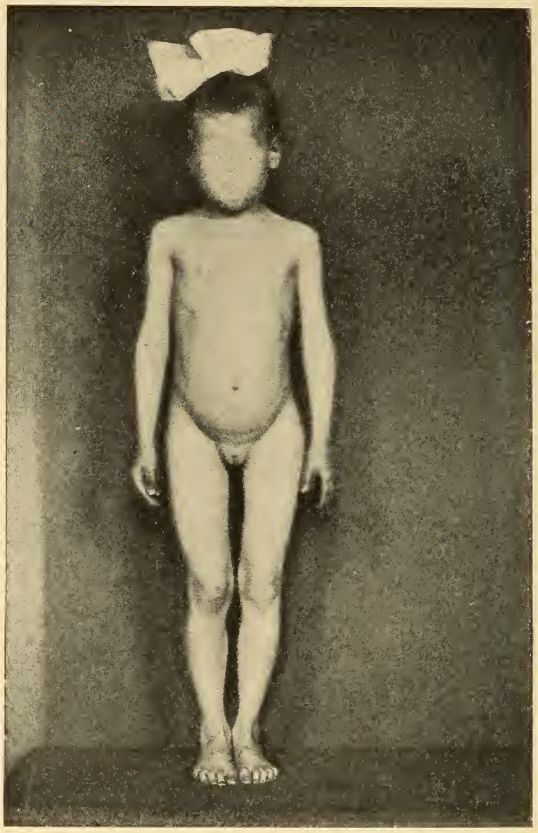


FIG. 447.—Six and One-half Years Old. Congenital dislocation of left hip. One year after reduction by operative mechanical stretching and manipulation.

strongly flexed and abducted position for several months, the limb should be rotated daily while still in the plaster, to check the contraction of the pelvic trochanteric muscles. After the danger of a relapse to a posterior dislocation is past, the limb can be fixed in the second position.

For the second position the limb is brought down to a position of abduction of forty-five degrees. In cases with a well-developed socket and well-reduced head the limb can be placed in this position imme-

diately after operation. It is the practice of some surgeons to allow the patients to walk about immediately after reduction, placing a high block under the flexed foot, in the expectation that the use of the limb will favor a deepening of the socket. For this the plaster needs to be cut so as to allow motion at the knee and free motion at the well hip. It is safer, however, to fix both the hip-joint and the knee of the affected side for a few weeks after the forcible reduction, carrying the

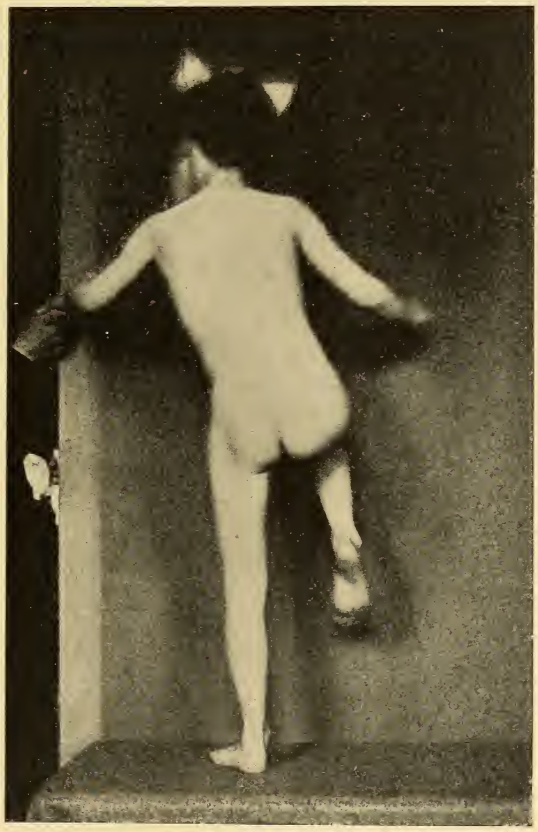


FIG. 448.—Showing Strength of Reduced Hip by the Trendelenburg Test. Motion and gait of reduced hip normal.

plaster well down the limb and around the opposite perineum. After the tissues have recovered from the laceration of reduction, the plaster can be shortened so as to allow the patient to enjoy more freedom. The length of time during which it is necessary that the plaster bandage should be worn varies, with each case, from two to six months or even a year

In order to prevent the contraction of the muscles when the limb is placed in the plaster-of-Paris spica, it is desirable not only that the

child should walk about as freely as possible after the first few weeks following the operation have passed, but that the limb be rotated inside the plaster-of-Paris spica by an attendant, who, holding the patient's ankle, endeavors to straighten the limb at the knee and gently turns the foot inward. After the time has passed when plaster fixation is no longer necessary, daily exercise should be given, directed to increasing the motion at the hip-joint. It is necessary to stimulate the muscles which are not being used, and to stretch by gradual exercise the muscles which may remain contracted. The patient should be given both passive and active exercises. In the passive exercises the manipulator should place one hand upon the pelvis with slight pressure above the trochanter, and with the other move the femur in the direction of flexion and adduction, the patient being recumbent. Movement should also be made to straighten the limb at the knee and turn the foot inward, bringing the limb gradually in the direction parallel with the other. Similar active exercises can be undertaken and conducted with care daily.

Relapses.—Although it may be claimed that a large number of cases of single congenital hip dislocations under ten years of age can be reduced (with or without the aid of mechanical force), it must be admitted that a considerable number of apparently cured cases relapse. The results have been divided by Lorenz into anatomical and functional cures, the latter term being applied to the cases in which the femoral head is near but not in the socket. But for the sake of accuracy it is desirable to avoid classing with successful cases those in which a failure in the attempted surgical procedure has resulted, even if the patient's condition may have improved.

While perfect results can be obtained in a considerable percentage of cases by forcible manipulative reduction, the causes of relapse need consideration. One of the most common is what may be termed imperfect reduction, *i.e.*, a reduction into the acetabulum with the folds of the enlarged capsule crowded into the socket in front of the femoral head. In some instances an hour-glass contraction of the capsule exists in congenital dislocation of the hip, too great and too firm to permit the passage in attempts at reduction of the femoral head through the constricted portion. It has been thought that the use of the limb in walking in the after-treatment enables the pressure of the femoral head to wear through the folded capsule. Evidence to support this is lacking, and, considering the toughness and nature of the folded capsule and the large percentage of relapses, it is probable that when this condition exists (a condition verified by pathological evidence and where open incision has followed attempts at forcible reduction) relapse is inevitable.

Relapse may follow where the capsular tissue fails to hold with suf-

ficient firmness in the acetabulum the reduced head after reduction. This takes place when a cotyloid ligament is not developed, and when

FIG. 449.—Skiagram One Year after Reduction.

the muscles are not sufficiently strong to keep the femoral head in place, or when tissues, contracted in the flexed and strongly abducted

position of after-treatment, prevent the placing of the limb in the normal position without causing displacement.

Care in after-treatment may prevent relapses in many instances of

FIG. 450.—Child of Five. Skiagram taken two years after reduction by incision. Right congenital dislocation of hip. Motion and gait normal.

this class. Careful examination of the cases during after-treatment by manipulation and with the skiagraph, the use of gymnastics, and mas-

sage will be of advantage in restoring the muscles to their normal condition.

Relapses result also from abnormality in the shape of the femoral head and in the shape of the acetabulum. It is impossible by manipulative reduction to place securely a distorted femoral head into an equally distorted and smaller acetabulum. Permanent reduction is also made difficult by the twist of the femur, which gives an abnormal direction to the femoral neck and consequent abnormal muscular relation. The importance of the femoral twist in causing relapse after congenital dislocation has been exaggerated. It has been found by the investigation of Mikulicz and also by Soutter that a femoral twist may exist to a considerable extent without causing noticeable disability. When a femoral twist of ninety degrees is present, it is impossible for

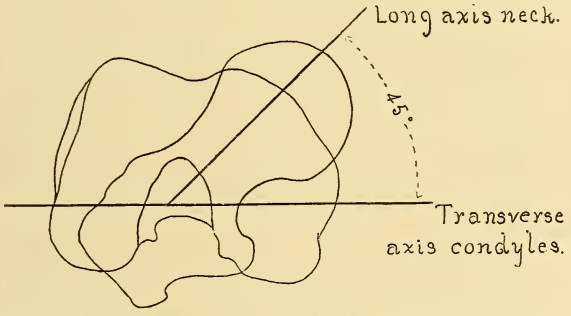


FIG. 451.—Twist of Neck in Congenitally Dislocated Femur, Looking from Above Downward.

the patient to walk normally with the femoral head in the socket. Under these circumstances an osteotomy of the femur is necessary.

OSTEOTOMY.—When osteotomy is necessary it can be performed by the use of an osteotome or a chisel, dividing the femur beneath the lesser trochanter by a linear osteotomy. If this operation is performed shortly after reduction, it will be found that some danger is incurred of displacing the reduced head by the use of the mallet and the osteotome. This danger can be avoided by the division of the femur a short distance above the condyle, employing a Gigli saw. This is easily accomplished by passing a large, curved needle around the femur, care being taken that the needle should be kept close to the bone on the inner side and thus avoid any danger of injuring the artery or nerve. No difficulty will be encountered in placing the wire, and, although the skin and muscular tissue may be somewhat injured in dividing the bone, the injury is no greater than that met in an ordinary osteotomy. It is safer to divide by the saw the greater part of the bone, leaving a portion to be broken that the remaining portion may serve as a splint to steady the fragments. The treatment after correcting the rotation by rotating the foot outward is the same as that of an ordinary fracture.

As a guide to prevent the twisting of the upper fragment, a small steel wire can be driven into the trochanter during the operation. Any twist of the upper fragment will be readily noticed.

Prognosis After Treatment.

The results obtained in the treatment of congenital dislocation of the hip show a gratifying increase in the percentage of permanent cures

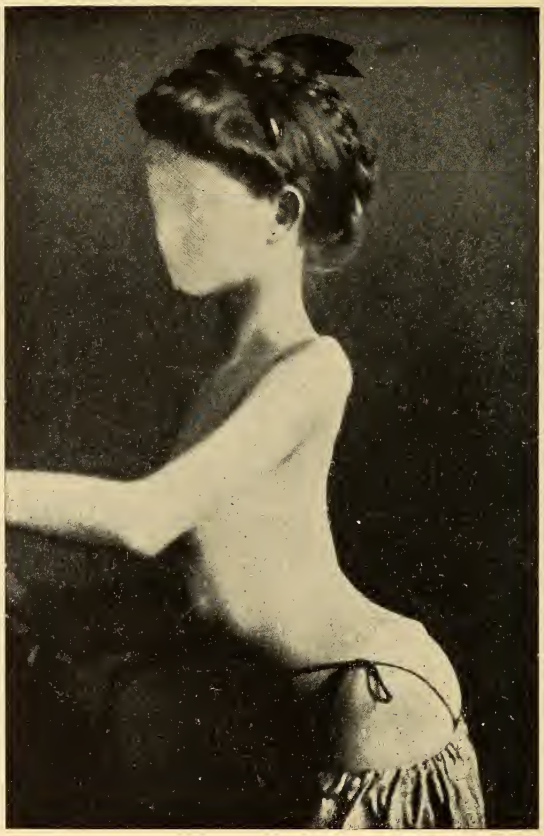


Fig. 452.—Untreated Case of Double Congenital Dislocation. Unable to walk without crutches.

as the knowledge of the pathological conditions of the deformity has been more thoroughly understood and as technical skill has increased.

The results obtained at the Children's Hospital in the treatment of congenital dislocation of the hip from 1884 to 1903 inclusive will serve as a commentary on the progress made in the treatment of the affection and will define the prognosis.

I. *From 1884 to 1896—21 cases.* Treated by mechanical appliances without operation, 7; by incision and curettage (Hoffa's early opera-

tion), 12; by manipulation under ether (Post), 2. Successful, 0; unsuccessful, 21.

II. *From 1896 to 1902—54 cases.* By open incision, 34: Successful, 11; unsuccessful, 6; result unknown, 17. By manipulation, 20: Successful, 1; unsuccessful, 7; result unknown, 12.

III. *Cases operated in 1902—22 cases.* By incision, 2: Successful, 0; unsuccessful, 2. By manipulation, 20: Successful, 8; unsuccessful, 2; relapse, 3; anterior transposition, 7.

IV. *Cases operated in 1903—33 cases.* By mechanical stretching and manipulation, 24: Successful, 16; unsuccessful, 3; transposition,

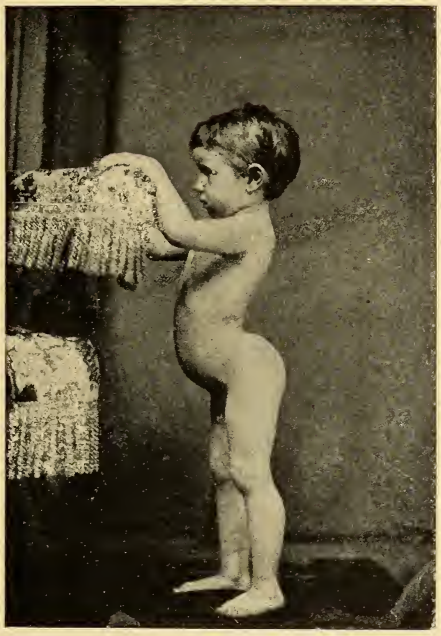


FIG. 453.—Double Congenital Dislocation of Hip. Child aged four. Untreated.

5. By manipulation, 8: Successful, 6; unsuccessful, 1; transposition, 1. By incision, 1: Unsuccessful, 1.

These figures indicate the development of the treatment of the affection from the earlier attempts at treatment without operation until the recognition of accepted methods of treatment. The results reported as obtained in the year 1903 were carefully examined by a committee of surgeons six months or a year after operation, and may be regarded as representing the permanent condition.[1]

[1] "Report of the Orthopedic Staff of the Boston Children's Hospital, Based upon Observations in One Hundred and Forty-six Cases." Boston Med. and Surg. Jour., vol. cli., No. 4, p. 85, July 28th, 1904.

It is difficult to determine from statistics the exact percentage of success to be expected from the open incision and from manipulative reductions. Statistics, however carefully compiled, vary in accuracy and in standards of success. An examination of the later statistics shows conclusively that the method of reduction by operative manipula-

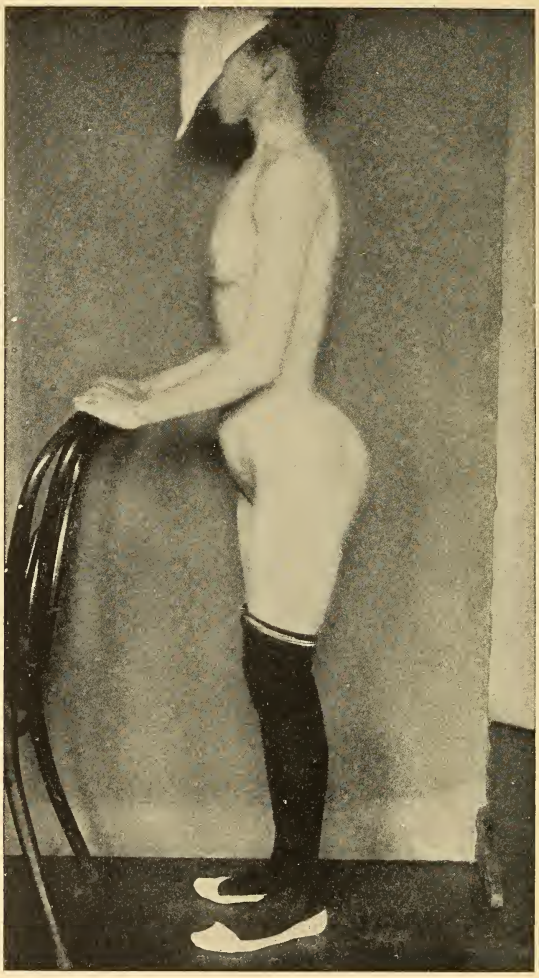


FIG. 454.—Same Patient, Age Twenty-eight. Untreated case. Patient able to walk actively with little limp.

tion (the so-called bloodless reduction) may be expected to give permanent anatomical cures in from ten to twenty per cent of the cases, and improved, *i.e.*, functional cures, in at least sixty per cent of the cases.

The claim that a greater percentage of cures can be obtained by open incision carefully performed with the latest improvements in tech-

nique is probably justified, although the results of the earlier attempts at open incision were not satisfactory.

The statistics offered by Hoffa of later results from the open incision with improved technique are highly satisfactory.

Treatment of Older Adult Cases.—Baer, of Baltimore, has operated with success upon an adult patient of twenty-five years of age with double congenital dislocation. The reduction was accomplished by means of an open incision with deepening of the acetabulum. The second hip was operated upon two years after the first. Although a satisfactory result was obtained in this instance, such success cannot be anticipated in a majority of instances, and the risk of stiffening the

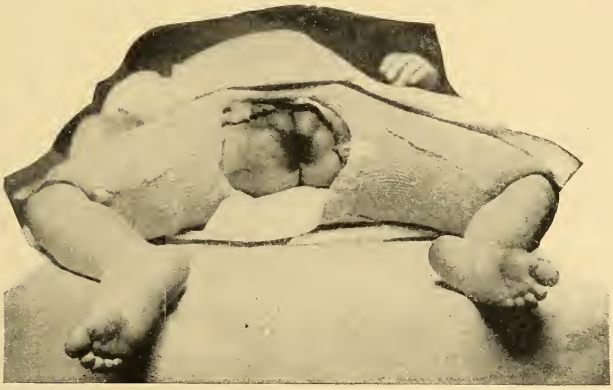


Fig. 455.—Plaster-of-Paris Fixation after Manipulative Reduction of Double Dislocation, Showing Amount of Ecchymosis.

joint is considerable. Some benefit is obtained by manipulative treatment, with or without an anæsthetic, in increasing the arc of motion and the usefulness of the limb. As a rule, however, the best treatment in adult or older cases is by gymnastics, which will strengthen the muscles in the lumbar and gluteal regions.

The use of a stiffened corset holding the hips and the dorsal region firmly, either made of stiffened leather or of cloth stiffened with steel, will be found of benefit in many of these cases in furnishing support to the back.

Summary.

Surgeons will vary somewhat in their choice of methods of operation, according to their experience and success with the methods of reduction by forcible manipulation or by open incision, but these facts may be said to be generally accepted:

As a rule no attempt at reduction is advisable under two years of age, as the tissues are not sufficiently developed to prevent relapse.

In the early cases, from two to five years of age, reduction is easily accomplished by forcible manipulation.

In older cases, from five to ten, except in children with weak muscles, although reduction by forcible manipulation is often not difficult, reduction is much easier after stretching by the Bartlett machine, and in some cases the reduction is impossible without the aid of the Bartlett machine.

In cases older than ten, as a rule, reduction by open incision is to be preferred; and in resistant cases under ten, where there is reason to believe alteration of the shape of the head and acetabulum or a firm and narrow hour-glass contraction of the capsule exist, reduction by open incision after a thorough stretching of the muscular tissues is advisable.

In cases of doubt as to which method to employ, the surgeon can regard it as a safe rule to follow if reduction is first attempted by forcible manipulation, employing open incision if relapse follows. Although the operation by open incision cannot, if performed with skill, be regarded as more dangerous than that of forcible manipulation, as a rule it is less acceptable to parents of patients.

Where the acetabulum is too shallow to hold the reduced head, it should be deepened if a lasting reposition is to be expected, but no surgeon should attempt this procedure or the reduction by open incision unless assured of complete asepsis in every surgical detail.

The length of time needed in after-treatment must be determined by the condition found after reduction, and must be left to individual judgment in each case.

Double cases are to be regarded as more than twice as difficult as single. Attempts at reduction by forcible manipulation should be made on both hips at the same time, but if open incision is employed, as a rule two separate operations are necessary.

KNEE.

Congenital dislocation of the knee is seen with greater frequency than that of some of the other joints.[1] It occurs most often in the form of hyperextension of the leg on the thigh, which has been considered by some writers a displacement rather than a true dislocation forward. In some cases the lower epiphysis of the femur is bent forward on the shaft.[2] It is in any event a congenital affection of importance when it occurs. It is frequently double, and the displacement may be directly forward or forward and to one side. The leg forms a right angle with the thigh, the apex of the angle being backward, and the condyles of the femur can be felt in the popliteal space; the patella is often small and occasionally absent, and lateral mobility may be present. Modifications in the shape of the bone, ligaments, and cartilages in the knee-

[1] Drehman: Zeitsch. f. orth. Chir., vii., 22 (98 cases).
[2] Delanglade: Rev. d'Orthopédie, May, 1903.

joint, even to the point of ankylosis, have been recorded in some of these cases. The deformity may be associated with malformation of

FIG. 456.—Congenital Dislocation of the Knees Forward in a Young Adult.

other parts, and the cause can be given no more clearly than that of other congenital deformities.

Forward displacement of the leg at the knee is to be treated by manipulation in the direction of correction and the application of a splint to the knee to hold the leg in a corrected position. Following

FIG. 457.—Congenital Dislocation of the Knee. (Genu recurvatum with club-foot.)

these measures apparatus should be applied to limit the lateral motion if it is present, restricting the amount of hyperextension and increasing the amount of flexion. Apparatus must be worn, of course, till the

structures about the joint have adapted themselves to the new condition.

Posterior dislocation of the tibia on the femur occurs at times. Lateral subluxation may be found in connection with other congenital deformities.[1]

PATELLA.

Dislocation of the patella is among the more common of the congenital dislocations; many cases reported as congenital have, however, been doubted.

The type most frequently seen is outward dislocation existing with some degree of knock-knee. It may be displaced inward or upward, in the latter case being associated with lengthening of the patella tendon. There may be, in connection with the dislocation outward, absence or flattening of the outer condyle of the femur.

FIG. 458.—Congenital Dislocation of both Knees with Club-foot. (Reiner.)

The disability may be slight or there may be marked impairment of the extension power of the leg on the thigh. Treatment by operation would be similar to that described in speaking of slipping patella.

CONGENITAL ABSENCE OF THE PATELLA.[2]

The patella may be absent or tardy in its development. If it is absent the knee appears broad and flat and there may be marked impairment of the function of the knee. In other cases the knee is useful. It may coexist with other malformations of the knee, especially genu recurvatum. It is often bilateral and is frequently associated with club-foot and similar deformities.

The treatment consists of apparatus to support the defective joint and massage and muscle training to the extensor muscles.

[1] Cone: Am. Medicine, November 5th, 1904, p. 812 (with literature).
[2] A. Thorndike: Orth. Trans., vol. xi.

ANKLE.

Inward and outward congenital dislocations of the ankle have been recorded in connection with absence of the tibia or fibula.[1]

SHOULDER.

True congenital dislocation of this joint is rare, and many cases reported as congenital have proved on investigation to be dislocations due to paralysis or due to injury to the shoulder at birth, resulting most often in a separation of the epiphysis. The dislocation found is the subspinous, but other varieties have been recorded, such as the subcoracoid and subacromial. Double dislocation of the shoulder has been described and in some cases associated with other malformations. In one case two children in one family were similarly affected. The glenoid cavity is likely to be malformed, as in a case reported by Smith, where there was hardly a trace of the normal glenoid cavity. In other cases it is approximately normal. The limitation of function is similar to that in traumatic dislocations. Cases of dislocation of the shoulder-joint in young infants have been reduced with or without incision, with improvement in the usefulness of the arm; cases of true congenital dislocation, however, improved by operation are few. Cases were operated on by Phelps by doing what was practically an arthrodesis through a posterior incision, and the redundant capsule was removed. Some similar cases have been reported, but most of them are open to the suspicion of not having been congenital. The chances of successful replacement would be greater in cases with a normal glenoid cavity and in cases undertaken early in life. In later childhood the prospect is less good.

In addition to the operative reduction, reduction by manipulation is to be considered, following the lines indicated in the operation for congenital dislocation of the hip. After replacement the arm should be held by a plaster bandage for some months in a position of abduction and outward rotation.[2]

ELBOW.

Congenital dislocations of the elbow are very rare and of comparatively little practical importance. The reported cases do not conform to any one type, following a wide range of variation.

1. Both bones may be dislocated forward or backward. This condition is extremely rare.

[1] Freiberg: Amer. Jour. of Orth. Sur., vol. i., No. 4, p. 335.

[2] Whitman: "Orthopedics," second edition, p. 473.—Porter: Orth. Transactions, xiii., 1898.—Cumston: Amer. Jour. of the Med. Sciences, June, 1903.—Kirmisson: "Traité des Mal. chir. d'Origine Congén.," Paris, 1898, p. 485.

2. The displacement of the head of the radius is a more frequent form of dislocation and may occur on both sides. The dislocation may be backward, forward, or outward, with or without abnormality of the other bones of the arm.

3. Backward dislocation of the radius and partial dislocation of the ulna with imperfect development of the external condyle have been recorded. The displacement may or may not be seriously disabling. In cases requiring radical operation, the head of the radius or the entire elbow-joint may be resected.

Cubitus Valgus—Cubitus Varus.

In connection with congenital dislocation of the elbow may be mentioned a deviation from the normal line of the arm occasionally seen. If the arm of the adult hangs at the side with the palm of the hand directed forward, the line of the forearm should form with the line of the arm an angle of about 169 degrees with a variation of 10 degrees in either direction. The outward deviation of the forearm is a few degrees greater in women than in men. *Cubitus valgus* is the name applied to the condition in which the forearm is displaced too far to the radial side; *cubitus varus*, the condition in which it is displaced to the ulnar side. Trauma is the most frequent cause of the marked varieties. They are also associated with rickets and the element of inheritance apparently plays a part. In case either deformity should be severe enough to require operative treatment, an osteotomy may be done similar to the Macewen operation for knock-knee.

WRIST.

Pure congenital dislocation of the wrist is extremely rare. The ordinary form in which it is seen is in connection with club-hand.

Spontaneous Subluxation of the Wrist.

A displacement of the wrist has been described by Madelung,[1] in which the hand is displaced to the palmar side of the forearm and probably to either the radial or the ulnar side laterally, generally to the former. In such cases the lower border of the radius and that of the ulna are prominent at the dorsum of the wrist, and the bones are somewhat separated from each other. The wrist is much increased in thickness and the function of the hand is impaired. Active and passive dorsal flexion are affected and some pain may be present, especially in dorsal flexion. The hand can be replaced only in the lighter grades of the affection. There is excessive mobility of the intercarpal joint and there may be slight forward bending of the lower extremity of the radius.

[1] Archiv f. klin. Chir., Bd. xxiii.

Aside from the pain which may be present, the symptoms are weakness and sensations of discomfort about the wrist. The causes of the affection are given as relaxation of the ligaments, stretching of the muscles by hard work, irregularity of growth at the lower end of the radius, and possibly a malposition lasting over from rickets. The treatment is at first hyperextension of the joint by means of bandages and splints, the use of massage and similar measures, and osteotomy in cases with bony deformity sufficient to require it.

CHAPTER XIX.

TALIPES.

Talipes equino-varus (Club-foot). — (Pathology. — Etiology. — Symptoms. — Diagnosis. — Prognosis. — Treatment.) — Talipes equinus (Varieties. — Etiology. — Pathology. — Symptoms. — Treatment). — Talipes calcaneus (Varieties. — Symptoms. — Treatment). — Talipes valgus. — Talipes varus. — Talipes cavus. Club-hand (Varieties. — Etiology. — Symptoms. — Diagnosis. — Treatment).

The name talipes signifies a deformity of the foot, and, although it was originally used to indicate a form of talipes now known as equino-varus or club-foot, the present use of this word is as a prefix to the descriptive adjective designating the variety of the deformity which exists. Of the pure forms of talipes one finds described talipes equinus, the plantar-flexed foot; talipes calcaneus, the dorsally flexed foot; talipes cavus, the foot with increased arch; talipes valgus, the everted foot; and talipes varus, the inverted foot.

Talipes equinus may exist with either valgus or varus, being then spoken of as equino-valgus or equino-varus, the elements of two deformities being present. Talipes calcaneus may exist in connection with valgus or very rarely with varus, being then known as calcaneo-valgus or calcaneo-varus.

TALIPES EQUINO-VARUS (CLUB-FOOT).

The term club-foot is popularly applied to a deformity characterized by an inversion, torsion, and depression of the front part of the foot with an elevation of the heel.

In walking on a foot thus deformed, the weight of the body is borne, not by the sole of the foot, but by the outer side, and in extreme cases by the dorsum of the foot.

The distortion is also known as "reel" foot — pes contortus, Klump-Fuss, pied bot, etc.

The deformity is either congenital or acquired.

Frequency.—Club-foot is by no means an uncommon distortion, and was mentioned in literature even in the days of Homer.[1] In 6,969 orthopedic patients applying at the out-patient department of the Children's Hospital, Boston, there were 488 cases of club-foot. Congenital club-foot is by far the most frequent of the congenital deformities of

[1] "Iliad," i., 599; xxi., 331.

the foot. It affects males more frequently than females, and the right foot is more frequently affected than the left. It is as often double as single. Acquired club-foot affects males and females in about equal proportion, the right foot is most often affected, and it is more fre-

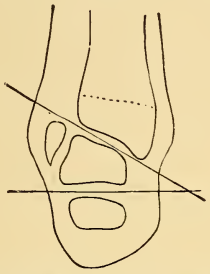


FIG. 459.—Section of Foot and Leg in Club-foot.

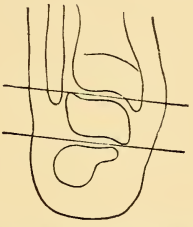


FIG. 460.—Section of Foot and Leg, Normal.

quently unilateral than bilateral. Chaussieur, among 22,923 newly born infants, reports 37 cases of club-foot. Lannelongue, among 15,229 births at the Paris Maternity Hospital, found 8 cases.

Pathology.—The deformity is a dislocation inward of the anterior part of the foot, the dislocation taking place at the medio-tarsal articulation. All the tissues are necessarily affected by the abnormal position, and the skin, muscles, tendons, and fasciæ are all altered.

In all cases of congenital club-foot, even in that of a full-term fœtus, the scaphoid bone will be found articulating with the side of the

FIG. 461.—Relation of Astragalus to Os Calcis. (Whitman.)

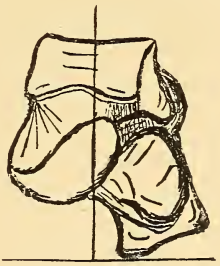


FIG. 462.—Relation of Astragalus to Os Calcis in Flat-foot. (Whitman.)

head of the astragalus rather than with the anterior surface. The articulation is also more toward the under side of the astragalus, the head of which is thus uncovered.

The scaphoid may be so far distorted to the side as to articulate at one end with the tip of the internal malleolus. The cuneiform bones, being intimately connected with the scaphoid, follow the displacement of the latter, and the same is true of the metatarsal bones and the pha-

langes, so that the long axis of the front of the foot forms a right angle, or even an acute angle, with the axis of the leg. The cuboid is necessarily displaced to the inner side and does not articulate with the front of the os calcis, the facet of which also inclines obliquely to the inner side.

In fully developed cases, and in older children or adults, there is a more marked and important alteration in the shape of the bones.

The os calcis, by the elevation of the tuberosity, is drawn from a horizontal into a position approaching the vertical. It is also more or less rotated on its vertical axis, so that its anterior extremity is directed outward and the posterior extremity inward, and thus the anterior articulating facet is oblique to the axis of the bone. The cuboid bone main-

FIG. 463.—Dissection of Club-foot.

tains its connection with the os calcis, but follows the inward direction of the anterior extremity of the foot.

There is no rotation of the astragalus on the vertical axis, but, as has been stated, it is depressed forward on its horizontal axis, so that only the posterior portion of its superior articular surface is in contact with the inferior articular surface of the tibia, and the anterior part of its anterior facet projects beneath the skin of the dorsum of the foot. Besides this displacement, the shape of the bone is altered by the twisting inward of the head and neck, so that the anterior articular surface looks inward instead of forward, and the disposition of the cartilage at the articulating surfaces of the head of the astragalus is necessarily altered. The three cuneiform and the three metatarsal bones, being closely connected with the scaphoid, are more twisted to the inside than is the case with the cuboid, though the metatarsals are not all

equally involved in the rotation from without inward and are spread out something as the branches of a fan, in such a way that the anterior part of the foot is enlarged more than normal. Besides these alterations in the position of the foot others take place secondarily, depending on pressure and the effect of locomotion on the distorted bones.

The different tendons assume an abnormal direction and in general are carried farther to the inside than is normal; this is especially true of the tibialis anticus, the common extensor of the toes, and the long extensor of the great toe. Synovial bursæ may form on the outer

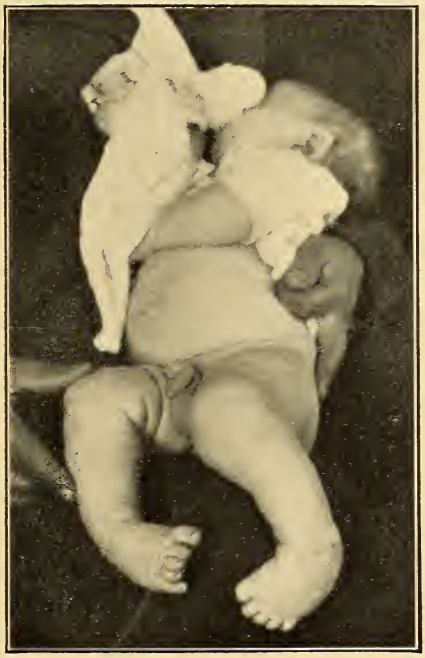


FIG. 464.—Double Congenital Club-foot.

edge and back of the foot, which may become inflamed and suppurate; corns and callosities are also formed on the skin, from the pressure of walking. No change has been found in the nerves or the spinal cord in cases of club-foot.

In extreme cases there may be slight alteration in the shape of the femur and a laxity at the knee-joint; the tibia has also been found altered, and the same is true of the fasciæ. The muscles are never found paralyzed in congenital club-foot, but the contracted muscles seem more developed than the lengthened muscles. The muscles of the leg atrophy from disuse, and the leg is much smaller and the foot shorter than normal.

In addition to the faulty shape of the bones there is a change in the ligaments and fasciæ, and this is not confined to the severe and most inveterate cases, but is always present. Not only are the plantar ligaments and fasciæ contracted, but the internal lateral and posterior ligaments are also contracted.

Etiology.—In regard to the etiology of congenital club-foot, various theories have been advanced in explanation of the deformity.

A popular idea is that the distortion is due to maternal impressions, but no conclusive evidence in regard to this has been obtained.[1]

Heredity, on the part of both the father and mother, has been established without doubt in a certain number of cases, but in a very large majority no trace of similar deformity in ancestors can be found.

The chief theories which have been advocated to explain the deformity in uterine life are as follows:

First.—Abnormal compression in the uterine cavity.

Second.—Retraction or paralysis of muscles depending or not on lesion of the nervous system occurring in utero.

Third.—A malformation depending upon arrest of development of the foot.

With regard to these theories it may be said that abnormal compression of the uterine walls may be a factor in producing the deformity, that evidence of muscular paralysis is wanting, and that the evidence that club-foot is due to a retarded rotation of the foot [2] and is the persistence of a fœtal condition is not supported by good evidence.[3]

It may be said that we are entirely ignorant of the causation of club-foot, and unable to give a reasonably satisfactory explanation of the phenomena of its development.[4]

Symptoms.—Club-foot gives rise to great inconvenience in walking. In uncorrected cases, however, the amount of skill and agility patients acquire in locomotion is surprising, even though the deformity remains unchanged. Bursæ and callosities form over the unprotected portions of the foot, and may inflame and cause much discomfort, limiting the amount of the patient's activity. A laxity of the knee-joint is sometimes developed in consequence of club-foot.

The gait of these patients is characteristic. In double cases the feet are lifted one over the other as a step is taken, giving a peculiar appearance, and perhaps suggesting the popular name of "reel" feet. The tendo Achillis is firm and hard to the touch; the plantar fascia

[1] Dabney: "Cyclopedia of Diseases of Children," vol. i.

[2] Brit. Med. Journ., 1886, ii. 10; Archives of Med., New York, Dec. 1, 1882; Boston Med. and Surg. Journ., Oct. 27, 1887.—Wolff: "Ueber die Ursachen, etc., des Klumpfusses," Berlin, 1903.

[3] Bessel Hagen: "Die Path. und Therap. des Klumpfusses," Heidelberg, 1899.

[4] R. W. Parker and Shattuck: Brit. Med. Jour., May 24th, 1884, p. 998.

will be found short and hard on palpation. The front of the foot projects to the inside of the vertical axis of the leg, the posterior end of the os calcis is raised and turned inward, the leg is turned outward, and the head of the astragalus and cuboid project under the skin. There is usually atrophy of the muscles of the leg. The external mal-

FIG. 465.—Congenital Club-foot. Cured club. Twenty-four years after correction in infancy by tenotomy, manual force and retention, walking appliance worn for two years. Patient able to walk without limp or discomfort twenty miles a day.

leolus is prominent and the internal malleolus not readily felt. The foot is more or less rigid in the deformed position, resisting gentle attempts at correction.

Diagnosis.—There is no difficulty in recognizing the deformity of club-foot. In infancy, a true club-foot is sometimes thought to exist when the trouble is simply a temporary spasm of the tibialis muscles which turn the foot in. This passes away in a short time and should occasion no anxiety.

The history of the case establishes a diagnosis between the congenital and non-congenital forms of club-foot. The paralytic form can be

recognized by the evidence of paralysis of the muscles on the anterior and external surface of the leg. Paralysis, it may be added, is the only common cause of acquired club-foot. The severity of cases of club-foot cannot be determined always by the apparent distortion. Cases resembling each other in outward appearance may prove less or more difficult of treatment. As a rule, however, it may be said that the younger the patient the less resistant the deformity, and it is often convenient to consider the cases as:

1st. Infantile—*i.e.*, infants in arms.

2d. Walking cases—*i.e.*, cases in young children in which the feet have been walked upon before the deformity has been corrected.

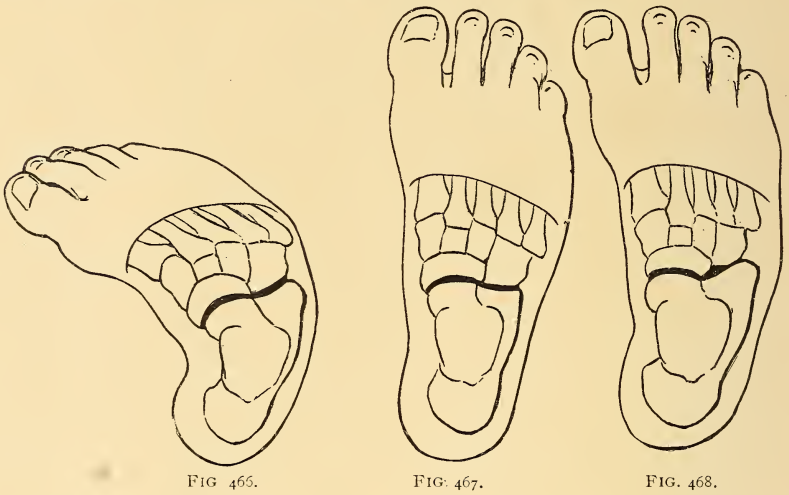


FIG 466. FIG. 467. FIG. 468.

FIG. 466.—Diagram Indicating Mid-tarsal Articulation in Club-foot and the alteration in the positions of the scaphoid and cuboid in their relation to the astragalus and os calcis—with alteration in the shape of front of os calcis.

FIG. 467.—Diagram of a Normal Foot.

FIG. 468.—Diagram of a Club-foot Partially Corrected, Leaving the Projection of Front of Os Calcis Unchanged, and the Consequent Imperfect Reduction of the Cuboid. A relapse necessarily follows.

3d. Resistant or relapsed cases—*i.e.*, those which have resisted treatment, or in which treatment has been inefficient, and in which the deformity has recurred.

4th. Neglected cases, in which the feet have grown for years in a severely distorted position.

Prognosis.—In regard to the prognosis of the deformity, it may be said that the distortion does not correct itself, and, if left uncorrected, remains the most obstinate of malformations. The deformity is one which is essentially curable; in fact, it may be said that it is always curable, provided care and attention can be given by both surgeon and nurse.

The amount of time needed for treatment varies according to the method employed. Formerly much time was needed in the treatment of inveterate cases, but since the introduction of open incision and tarsal resection, when necessary, correction can be accomplished in a short time.

In infantile cases the time required for correction is relatively short, but retentive appliances are needed for a longer time. It may be said in general that the older the cases and the larger the foot the more difficult the correction, but the less the danger of relapse after correction.

In regard to the permanence of the cure and the danger of relapse, it may be said that if perfect correction is attained relapse is exceptional, if moderate care is used in the employment for a sufficient time of retentive appliance.[1]

But it must be borne in mind, especially in the case of young children, not only that the correction must be complete, but that efficient appliances for keeping the proper position of the foot in walking (retentive or walking appliances to be described) must be worn until the gait and attitude are perfect. In club-foot half-cures are practically no cures. Relapsed cases are invariably resistant and difficult to correct.

Treatment.—The object of treatment is the correction of the distortion and the retention of the foot in a corrected position until any return of the deformity is impossible, the tendency to relapse being very strong.

The treatment should be purely mechanical, or both operative and mechanical.

The treatment of club-foot, therefore, requires:

1. A rectification of the misplaced bones and a lengthening of shortened and contracted tissues.

2. A retention in a normal position until the abnormal facet of the astragalus and the other tissues become, under the pressure of new position, normal.

At the present time few procedures in surgery are as precise in their indications and as certain in their results as the methods for the correcting of club-foot.

The correction of club-foot should be divided into two steps, whether the treatment is mechanical or operative.

1st. Correction of the varus deformity.

2d. Correction of the equinus deformity.

In other words, the front of the foot should be twisted out and afterward be raised. This will be found of practical importance, as the foot is more easily twisted before than after the equinus deformity is overcome.

[1] Trans. Am. Orthop. Assn., vol. i., "Club foot."

Operative treatment in some form is the method to be selected in cases of congenital club-foot, except in young infants and in older children when some contraindication to operation exists.

The mechanical procedures for correcting club-foot are as follows:

Manual manipulation.

Plaster-of-Paris bandages.

Apparatus.

The operative procedures which are to be considered in treating club-foot are:

Tenotomy.

Division of the ligaments.

Open incision.

Forcible correction and osteotomy.

Mechanical Correction.

Manual.—The simplest method of correction is by the use of the hands, and in the case of a new-born infant with club-feet the mother may be directed to manipulate the foot, and having rectified the de-

Fig. 469.—Double Club-foot in Plaster Bandages After Operative Correction.

formity by gentle force several times daily, to hold it as straight as possible for a minute or two each time. This process continued daily over a period of months is in intelligent hands capable of restoring the foot to its normal mobility and position, after which retention treatment should be begun.

Plaster-of-Paris Bandages.—Another method in correcting club-foot is by repeated fixation in a plaster-of-Paris bandage, the foot being held as nearly in a corrected position as possible at each application of the bandage until the bandage hardens. The application of a plaster-of-Paris bandage must, however, be made with care and skill to prove efficient, whether applied for correction without operation or to maintain the overcorrected position obtained by operation.

The foot should be wound with plenty of sheet wadding, pads should be

FIG. 470.—Congenital Double Club-foot Walking Before Operation.

FIG. 471.—Double Club-foot. Two months after correction by forcible manipulation, wearing walking retentive appliances. Same case as Fig. 470.

placed between the toes, and the foot should be held overcorrected from the first during the application of the bandage by an assistant, who shifts the fingers from place to place to keep out of the way of the bandage, yet who maintains the overcorrection. To overcorrect the position of the foot when the plaster is setting is to cause folds of the bandage to turn in and either compress or cut the tissues after the plaster is set. It is important to keep the inner end of the foot part of the bandage long, to press outward the front of the foot, and thus antagonize the varus.

The circulation of the toes must be carefully watched after the application of such a bandage.

An extension of this method is to be obtained after the plaster has set by removing an elliptical piece of the plaster bandage over the anterior and outer aspect of the ankle and dividing the rest of the bandage at the same level by a circular cut. By crowding the front of the foot-piece up and out and holding it in the improved position by fresh bandages applied over the old plaster, further correction is obtainable.

FIG. 472.—Splints for Equino-varus Applied.

The bandage should reach above the knee, where the limb should be slightly bent to prevent the plaster bandage (which should be renewed every two or three weeks) from rolling around the limb, and to prevent the child from kicking it off. In the case of small children with plump legs, and in resistant cases, it will, however, be found difficult to prevent the heel from being drawn away from the bandage, and stretching of the tendo Achillis will by this method be tedious.

This method has the disadvantage of being tiresome, but it has many advantages in being a practical method, readily applied, and not leaving details of application to the patient's parents. It is evident that

correction in this way, if persistently applied, is possible, but, except in very young children, it is advisable to perform tenotomy first. If the Chinese [1] can produce an extreme deformity by bandaging the children's feet, the same method could be employed for the correction of deformity.

Apparatus.—Mechanical correction (without tenotomy) by means of appliances has been successfully employed in very young cases. The method, however, requires much persistence on the part of the surgeon if a perfect cure is expected, and is not to be advised.

Although treatment by apparatus is not sufficiently effective to cure any but the mildest forms of congenital club-foot in young children, it is often enough to bring about a cure in acquired club-foot of moderate severity. The form of apparatus is the same whether used as a corrective or as a retentive appliance, and will be described here. The object of such apparatus is to retain the tarsal bones in proper position until the muscles and ligaments have adapted themselves to the normal posi-

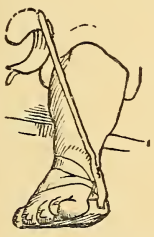


FIG. 473.—Taylor Shoe in Process of Adjustment. The sole plate applied and the foot strapped to the sole plate.

FIG. 474.—The Upright Brought into Place and Acting as a Lever, Turning the Foot to the Outer Side.

tion, and until articular facets have been formed in the proper direction, or the astragalus and os calcis have assumed, under altered pressure, a relatively normal shape.

Corrective apparatus is essential after the desired position of the foot has been obtained by other means.

The corrected foot tends to relapse in two directions—inversion and elevation of the heel. If this is unchecked and walking is done in improper attitudes, hurtful pressure and strain fall upon the bones and ligaments of the foot, and relapse takes place. This should not occur if proper retention and walking with a proper attitude of the foot are cared for.

As these appliances are to be worn a long time, they should be light, readily adjusted by the nurse, not unsightly, and in no way limiting locomotion, walking, or running. The best are worn within the shoe.

[1] Percy Brown: Journal of Med. Research, 1904.

It is unnecessary to describe all the various appliances that have been used. Mention will here be made of one which has been found of service in the writers' experience, after a careful trial of the usual varieties of appliances designed for the purpose.

It is to be remembered that in all appliances it is necessary that the pressure preventing a faulty position of the foot should be applied precisely, pressing the front of the foot and tip of the heel outward, the front of the foot, especially the outer edge including the cuboid, upward, and the back of the foot, *i.e.*, the end of the os calcis, downward, and the outer dorsum of the foot inward.

Inward pressure should be exerted upon the outer edge of the front of the os calcis and astragalus, and not upon the cuboid, as is too commonly done in inefficient apparatus. As the latter bone is in front of the mediotarsal joint, inward pressure upon it not only fails to correct the deformity but tends to increase it. This explains the occurrence of many relapses.

The apparatus (Chapter XXI., **27**), which is a modification of Taylor's varus shoe, consists of a sole plate small enough to fit in a shoe secured to a jointed upright furnished with a stop to prevent the plate from dropping into the equinus position. The foot is secured to the plate by means of a strap which, secured to the inner side of the plate, passes from the inside of the great toe obliquely to the outside of the foot so as to press upon the anterior outer surface of the os calcis and through a loop at the outside, and then is brought across the ankle through the metal loop and secured in the clasp. A cross strap to keep the toes down, and a cross ankle strap to keep the heel down, are sometimes necessary in addition, with a back strap behind the heel.

The appliance can be worn inside of a shoe, opened like a bicycle shoe well down to the toes.

A combination of operative and mechanical methods of treatment is at present the most common mode of treating club-foot at all ages. The operative interference most frequently resorted to is tenotomy and subcutaneous division of the fasciæ or ligaments.

Operative Treatment.—*Tenotomy.* — The structures to be divided are, of course, those which hold the foot in its deformed position. The tendons may be divided by entering the tenotome under the skin and cutting the tendon from without inward, or by passing the tenotome under the tendon and cutting outward. The advantage of the former is that there is no danger of making a large skin incision by a slip of the tenotome. There is, however, danger of incomplete cutting of the tendon. The tendon which is most frequently divided in equino-varus is the tendo Achillis.

Section of the Tendo Achillis.—The patient should lie upon his face or side and an assistant should hold the foot; the surgeon enters the

knife parallel to the border of the tendon, passing the tenotome flatwise between the tendon and the skin. This having been done, the blade of the knife is turned toward the posterior surface of the tendon and the assistant raises the end of the foot so as to stretch the tendo Achillis slightly. The left index finger presses on the skin over the back of the tenotome, and in this way the sensation of the cutting of the tendon can be felt.

The only precaution necessary is to be assured that the tendon is completely divided. When the operation is done, the extravasated blood is squeezed out of the opening and a small amount of aseptic gauze is placed over the wound. The operation should be done aseptically and an aseptic dressing applied.

Section of the Tibialis Posticus.—Section of the tibialis posticus is done in the following way: If the muscle is divided in the leg, the foot is placed on its external border. The surgeon divides the skin by

FIG. 475.

FIG. 476.

FIG. 475.—Imprint of Foot of a Child Sixteen Years Old. Treated when one year old for congenital club-foot.

FIG. 476.—Imprint of Normal Foot.

means of a pointed tenotome 2 cm. above the tip of the internal malleolus and on a vertical line situated half-way between the posterior border of the malleolus and the corresponding border of the tendo Achillis. The tenotome should be directed perpendicularly downward to the depth of 1 or 1.5 cm. Then the handle of the instrument should be turned so as to describe the arc of a circle and the tendon divided ver-

tically inward. The assistant at the same time turns the foot forcibly in the direction of abduction. If the incision is made too near the malleolus, the internal saphenous vein and nerve may be cut. If the incision is made too near the tendo Achillis, there is danger of dividing the tendon of the long flexors of the toes and the posterior tibial artery and nerve.

The writers can record the puncture of the posterior tibial artery by the point of a tenotome and the formation of a small aneurism which required ligation, but caused no subsequent annoyance.

The Tendon of the Tibialis Anticus.—The tendon of the tibialis anticus is divided more easily. For this purpose it is sufficient to be

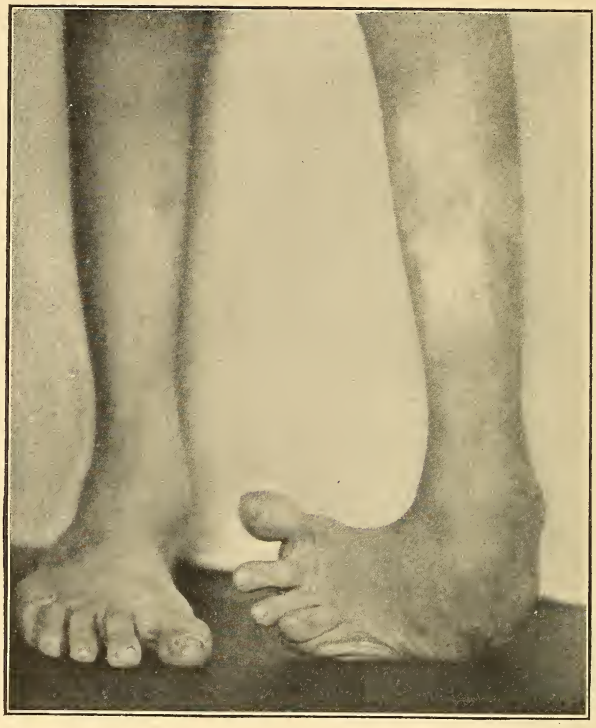


FIG. 477.—Relapsed Resistant Congenital Club-foot in a Boy of Eight. Front view.

guided by the prominence of the tendon put on a stretch by abducting the foot. To avoid the wounding of the deep parts, it is better to enter the tenotome under the tendon.

Division of the Plantar Fascia.—It is often necessary to divide also the plantar fascia, preferably before division of the tendo Achillis, as the latter acts as a means of support for stretching the foot when the plantar fascia is divided. The plantar fascia is divided in the same way

that the tendons are incised. The most prominent portion of the fascia is the point of election for subcutaneous incision. The fascia, it must be borne in mind, is not a narrow band, but a broad ligament needing a long subcutaneous incision. The tenotome should be inserted on the inner side of the sole nearly half-way between the os calcis and the ball of the foot, but nearer to the os calcis. The tenotome is to be pushed subcutaneously nearly across the sole, the edge of the knife

FIG. 478.– Same Case. Three weeks after forcible correction, immediately after removal of plaster retention bandages.

turned toward the fascia, and the knife drawn across the fascia, which will be felt to give way as it is divided; an assistant should make upward pressure upon the ball of the foot, in order to put the fascia on the stretch. As the artery lies deeply, there is no danger of injuring it, if ordinary care is used.

The tenotomes used should be strong at the neck, and the cutting edge should not be too long, as the skin is necessarily divided if they are too long; infantile cases require a much smaller instrument. The blunt-pointed tenotome is but little used now, and the sharp-pointed ones are used for all subcutaneous work.

Tenotomes as furnished by instrument-makers are ordinarily much too large, and though serviceable in myotomy, are better for tenotomy in children if smaller.

The Repair of Divided Tendons.[1]—When a tendon is divided, the

[1] Seggel: Beitr. z. klin. Chir., xxxvii., 1 and 2.

cut ends are separated to a variable extent, depending upon the retraction of the muscle to which it belongs, upon the position in which the limb is placed, and upon the surrounding attachments of the tendon. Extending beneath the ends of the tendon is its tubular sheath of connective tissue, and it is this which chiefly furnishes the reparative material.

The sheath becomes vascular and succulent, and after the absorption of the blood that has been effused within it, the interval between

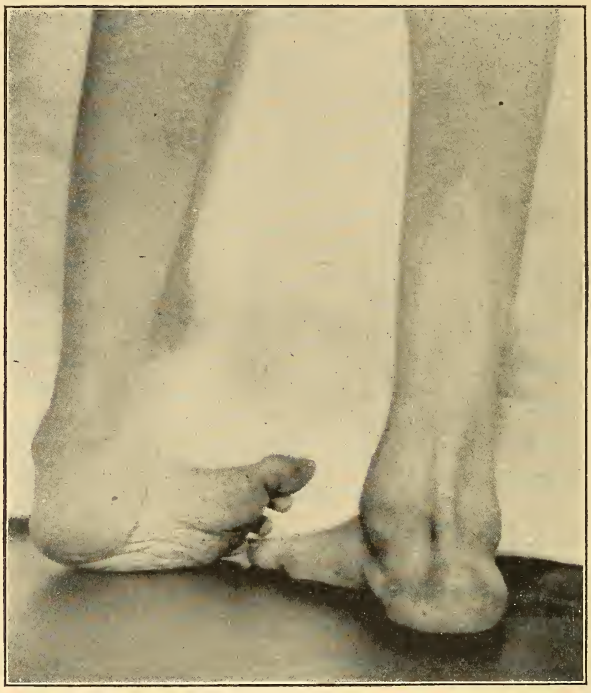


FIG. 479.—Relapsed Resistant Congenital Club-foot in a Boy of Eight. Rear view.

the divided ends of the tendons becomes filled with lymph, which gradually becomes fibrillated and forms a firm bond of union between them.

The new material so closely resembles the old tendon and is so intimately blended with it that for a time it would be difficult to distinguish them, except for a certain translucency which is possessed by the former, and is not natural to the latter. By this means the divided tendon is increased in length to the extent of the interval by which its ends are separated, and elongation will vary according to the amount of separation.

If after the operation treatment is carried out with ordinary care and skill on a healthy subject, a useful muscle is obtained.

Adhesions may, and doubtless often do, form between the divided tendons and the surrounding structure, but in ordinary cases they are not of consequence, for they give way in the use of the foot, and do not interfere with the function of the muscle.

Much undeserved opprobrium for a time fell upon the procedure of tenotomy. In half-cured and relapsed cases atrophy and functional disability of the muscles will be found; but there is no evidence to demonstrate that tenotomy, when properly performed, exerts an unfavorable influence upon the muscle.

Division of the Ligaments.—Division of the ligaments [1] is of use in the correction of club-foot.

For division of the astragalo-scaphoid ligament, the skin and soft tissues should be punctured down to the bone by the insertion of the

FIG. 480.—Soles of Relapsed Resistant Congenital Club-foot in a Boy of Eight.

tenotome. It should then be inserted in front of the internal malleolus and pushed directly to the underlying bone, and swept subcutaneously around the bone, keeping close to it. The knife should be kept between the skin and ligaments, and the latter divided by a sawing motion of the tenotome. This division, if satisfactorily and thoroughly made, may serve in certain cases as a substitute for the division of the tibialis tendons.

The calcaneo-cuboid ligament should also be divided in severe cases. The tenotome should be inserted a short distance behind the head of the fifth metatarsal bone, near the articulation of the os calcis and cuboid, which can be felt on palpation. The sharp-pointed tenotome should be inserted to the bone, and then by careful motion the whole ligament should be divided.

[1] London Path. Soc., British Med. Jour., 1886, vol. ii., p. 10.

Subcutaneous tenotomy of all the parts which obstruct the complete restoration is performed. This in most cases consists of division under an anæsthetic of the plantar fascia, the ligament of the scapho-astragaloid joint, and last, the tendo Achillis. After the tenotomy of the first three the foot is forcibly corrected by the hand, and a division of the resisting parts carried to such a point that the foot can be easily brought beyond the normal plane, after which tenotomy of the tendo Achillis is done and the foot placed in plaster in an overcorrected position.

In case the restoration has not been perfect, as sometimes happens with more resistant feet, it is well to remove the plaster at the end of ten days and apply the brace which is to be worn, reapplying the apparatus every two or three days. In this way, before complete consolidation has taken place, a certain amount of gain can be made and overcorrection be obtained at the end of a few weeks, which at first was impossible. If, however, the restoration has been complete it is better to keep the bandages on for from six to twelve weeks, in order that the foot may not be disturbed from its overcorrected position. When the bandages are removed great care should be taken that the foot is not allowed to drop from its overcorrected position, and thus make traction on the ligaments and soft parts in which contraction is desired.

When the plaster bandages are removed the retention appliance, described above, is to be used so long as there is any tendency to an incorrect position.

The permanence of the correction depends on the establishment of an accurate balance of the antagonism of muscles and other soft parts when the foot is in normal position. The after-treatment by retention must be persisted in until the child is able, without special effort, to walk with the foot in a natural position; otherwise a relapse will occur.

The sooner the foot is corrected the better, provided the patient's general condition is satisfactory, and that treatment is not liable to be interrupted by intercurrent infantile disorders; practically, treatment should be undertaken as soon as an infant is nursing well and is in reasonable health.

The use of retention apparatus will be necessary for some years and should be discontinued gradually. The parent may aid in the treatment by daily manipulating the feet into the overcorrected position. The treatment described covers in general all that is necessary for infantile club-foot.

The length of time during which the appliance is needed in after-treatment varies and is in general in inverse proportion to the size of the foot or the difficulty of correction, infants in arms needing a retention appliance relatively longer than is necessary in adult cases, in which, if correct gait with proper weight-bearing upon the sole is secured for a few months, relapses are not to be expected.

Summary of Mechanical Treatment.—In simple cases one may attempt correction (1) by manual manipulation repeated several times daily, (2) by plaster bandages applied at intervals of two or three weeks, (3) by the use of a corrective brace constantly worn, (4) by the subcutaneous division of tendons, fasciæ, and ligaments followed by immediate overcorrection in a plaster bandage. Without after-treatment relapse will follow in practically all cases. After-treatment consists in the use of a retention brace and daily manipulation of the foot.

Operative Correction.

In cases too resistant to be corrected by the means described the following radical measures may be employed:

1st. Open incision.

2d. The use of extreme force.

3d. Tarsal osteotomy.

Open Incision.—The chief difficulty is in obstinate cases to stretch the contracted tissue on the concave side of the distortion. Phelps' open incision on the inner and plantar surface is of use in these cases.

The advantage of open incision in club-foot is the facility of complete and thorough division of all the soft tissues to the bone. The method by which this is done is as follows: The skin is divided along the inner side of the foot, from the tip of the malleolus well down on the inner edge of the first metacarpal bone. After the skin is incised, the other tissues are cut with care, using a director if necessary. The insertion of the tibialis tendon is found and cut across. The artery can be spared by careful dissection, but if necessary it can be divided and tied. The plantar fascia on the sole of the foot should be divided by the use of a tenotome, or long, thin knife. A cross incision toward the sole of the foot from the middle of the long incision is sometimes necessary, but it is desirable to avoid this if possible. A triangular incision with its apex upward toward the ankle, instead of the cross-cut of the skin and fascia, is equally efficient and diminishes the gap after correcting the foot.[1]

Forcible Manipulation.—Even if tenotomy and thorough open incision are done, a certain amount of resistance remains from the interosseous ligament connecting the tarsal bones. Considerable force is often necessary to bring the foot into an overcorrected position. This can be done either by manual force or by the aid of mechanical force. Several wrenches for this purpose have been devised; that of Thomas is the simplest and is sufficiently efficient when no bone obstruction exists. The foot is then brought into as normal a position as possible, thorough aseptic dressings are applied, and the foot is then

[1] Jonas: Annals of Surgery, April. 1897, 449.

fixed in a plaster-of-Paris bandage reaching above the knee and holding the well-padded and aseptically dressed foot in an overcorrected position. If the dressing is provided with efficient protectors and sufficient dressings, no change in the bandage need be made for a fortnight or longer. If necessary, however, a window can be cut in the plaster over the wound and the dressings changed. After the plaster of Paris is discarded the retention shoe is to be worn.

The use of manual force without any previous cutting operation will rectify the deformity in club-foot, and such a method is in use. The inward twist of the foot, at the mediotarsal joint, is first corrected by

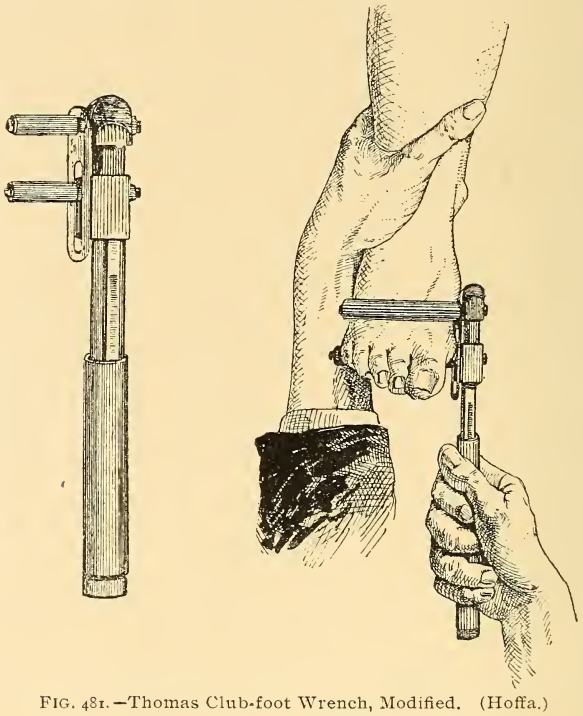


FIG. 481.—Thomas Club-foot Wrench, Modified. (Hoffa.)

grasping the heel in one hand and the forefoot in the other and stretching the inner side of the foot, either by the hands alone or by bending it over the padded edge of a triangular block of wood.

The inversion of the sole of the foot is then corrected by a similar series of manipulations, until the sole of the foot is everted and will stay in that position without the use of force.

The plantar fascia is next stretched and the height of the arch reduced by flexing the foot dorsally against the force of the tendo Achillis.

The reduction of the astragalus to its proper position between the malleoli is next undertaken. The tendo Achillis is divided by a tenotome, and, if necessary, the posterior ligament of the ankle-joint.

The child is now turned on the face, and the front of the thigh lies on the table with the knee flexed and the leg vertical. The operator hooks his fingers around the os calcis while the hand lies on the sole of the foot to force it into dorsal flexion. This is done by a series of forci-

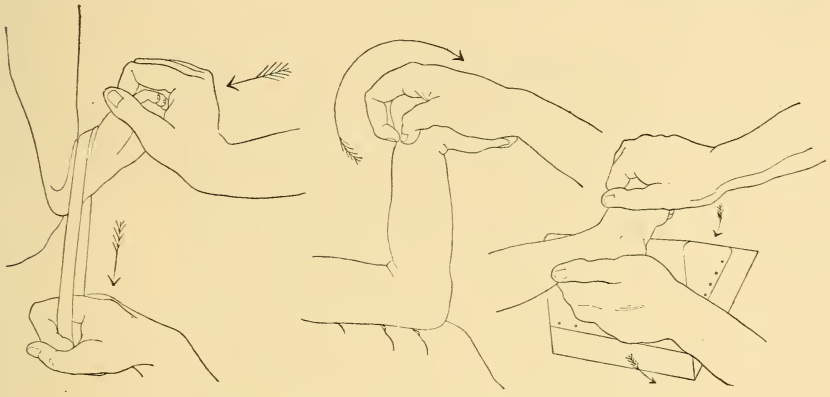


FIG. 482.—Manipulative Correction of Club-foot. (After Lorenz.)

ble pressings downward on the sole of the foot, until the dorsum of the foot nearly touches the tibia. The foot is now limp and can be held in an overcorrected position without the use of force. In this position a plaster bandage is applied.

The disadvantages of the operation lie in the unnecessary violence used to obtain a result which can more easily be reached by cutting resisting structures. The use of manipulative force is a well-recognized and useful preliminary to all forms of operation for club-foot. The experience of the writers has led them to prefer the removal of a wedge

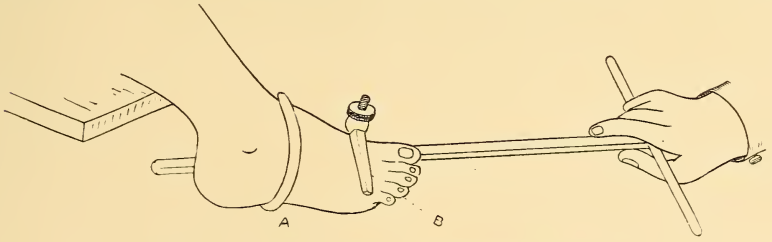


FIG. 483.—Lever Correction Apparatus (Applied),

of bone to the use of extreme force in cases which are still resistant after the use of the measures just described.[1]

In applying the bandages, it is of course important that the foot should be held in an overcorrected position until the plaster becomes hard, as no further correction can take place under the bandage. In the majority of cases perfect correction or overcorrection is possible,

[1] Phillipson: Deut. Zeitschr. f. Chir., xxviii.

and the foot can be held in proper position for the application of the fixation bandage without much force.

Osteotomy.—When but a slight amount of osseous distortion is present forcible correction aided by tenotomy or open incision will be sufficient to overcome the deformity, but in the more resistant cases

Fig. 484.—Double Congenital Club-foot Before Operation.

changes in the shape of the tarsal bones forming the mediotarsal joint prevent perfect cure, and operation upon the bones is necessary.

Astragaloid Osteotomy.—An examination of the anatomy of resistant club-foot shows that the facet of the astragalus in the astragaloscaphoid articulation is on the side instead of in front. There is also some obliquity of the neck of the astragalus. If this obstruction of the bone can be corrected and the front of the foot brought into place, there would be less tendency to relapse.

It is essential, in every inveterate case of club-foot, that if the foot is to be unfolded, the shortened tissues in the arch of the foot and in the inner side of the foot be stretched, torn, or divided. This can be done safely by means of tenotomy, forcible stretching, or open incision;

but the deformity of the astragalus still remains. In many cases, even if somewhat resistant, if the deformity is rectified and the foot held a sufficient time in the proper position, and a proper walking shoe used for a year, a new facet of the astragalus will be formed and a cure effected. In a few cases this is not the case, and in such instances osteotomy of the neck of the astragalus suggests itself as a suitable operation.

The procedure will not be found a difficult one. Tenotomy or open incision and division of the fascia and ligaments should be done, and

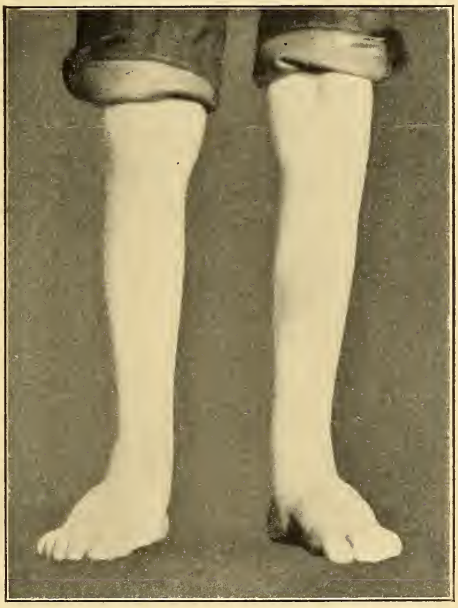


FIG. 485.—Same Case Six Weeks After Operation by Forcible Correction.

the foot stretched and manipulated into as nearly normal a position as possible. An incision through the skin is made from the tip of the malleolus to the inner side of the head of the first metatarsal, which will be found in severe cases close to the malleolus. The incision is close to and nearly parallel to the tibialis anticus tendon, and in the direction of the metatarsal. The incision should be made to the bone and the foot straightened, as the metacarpal bone is separated from the malleolus. The scaphoid will be seen before the astragalus is encountered, if the deformity is great, and it will be first within the reach of the knife in all cases. If the foot is still further stretched, the scaphoid begins to uncover the side of the astragalus, and the neck of the astragalus is seen; a small osteotome is entered and placed upon the neck of the astragalus, to the proximal side of the scaphoid articulation, and the

neck of the astragalus divided or nearly divided. The foot is then forcibly straightened, and the neck of the astragalus unchiselled is fractured. The result is similar to that in Macewen's operation for knock-knee, and the distortion at the neck of the astragalus is removed. It is manifest that the line of section of the bone at the neck of the astragalus should be transverse to the axis of the bone, and at such a plane that when the equinus deformity is corrected the resulting gap at the section should not be greater than necessary. The foot should be fixed in an overcorrected position. A wedge-shaped resection of the neck of the astragalus through a skin incision in the outer and upper surface of the foot has been performed, but linear osteotomy would seem to be preferable.

FIG. 486.—From Photograph after Removal of Astragalus of Left Foot for Club-foot.

Osteotomy of the Head of the Os Calcis.—The relation of the cuboid to the os calcis is frequently masked, lying deeper than that of the scaphoid and astragalus, and it may in treatment be but partially corrected. The distortion of the os calcis at its anterior aspect, if not corrected, increases and forms an obstacle to the complete restoration of the cuboid to the normal position, although the rest of the deformity may have been corrected.

When the cuboid is cartilaginous and the ligaments are well stretched, the defect at the anterior portion of the os calcis can be overcome by forcibly correcting the foot and retaining it in the corrected position by means of a plaster-of-Paris bandage, care being taken, however, that the cuboid be restored to place, and in time it will be found that the cartilaginous abnormality in the shape of the os calcis is gradually changed under corrected pressure.

When distortion of the head of the os calcis is great, no amount of mechanical treatment can overcome the obstacle, if it is of bone and if the ligaments are strong, binding the bones in a distorted position. It is manifest under these circumstances that the rational treatment is a removal, not of the astragalus or cuboid, but of a part of the projecting portion of the head of the os calcis.

After complete stretching or division by tenotomy, force, or open incision of the contracted tissues on the inner and under side of the foot, tendons, ligaments, and fasciæ, if it is found that the front of the foot cannot be brought to a perfectly corrected or overcorrected position, an incision should be made on the outer side of the foot, passing from behind the external malleolus forward and downward. The incision should be a curved one, and the chief convexity should be at the forward portion of the os calcis. This incision should reach to the

FIG. 487.—Sole Imprint after Removal of Astragalus for Club-foot.

FIG. 488.—Sole Imprint of Case of Club-foot Corrected by Tenotomy, without Contraction but with Inversion of the Foot.

bone and should expose the peroneal tendons. These can either be drawn to the side or divided to be stitched later. The upper portion of the incision should reach behind the external malleolus, and should ex-

FIG. 489.—Imprint of Left Foot before Operation.

FIG. 490.—Imprint of Left Foot after Operation.

tend far enough up to allow sufficient retraction of the flap to give room for the osteotomy. After the bone has been reached, and the periosteum divided and pushed aside, an osteotome should be inserted far enough back to remove a sufficient amount of bone. The direction of the insertion of the osteotome should be such as to allow the placing of the cuboid, after the bone has been removed, in a normal position. This step of the operation requires some nicety and judgment, as it is of importance that the front plane of the bone, after the wedge has been re-

FIG. 491.—Case of Bad Relapsed Congenital Club-foot in a Woman of Thirty-four, Corrected by Force with the Use of a Wrench. Photograph taken three months after correction.

moved, should be in the direction of the normal facet of the front of the os calcis. A wedge-shaped portion of bone should be removed from the anterior and outer part of the os calcis, and the cartilaginous ends saved in order to allow a proper amount of motion between the cuboid and the os calcis after recovery. The wedge-shaped portion of bone that should be removed should be ample and enough to allow the replacement of the front of the foot in a normal or overcorrected position and the restoration of the proper direction of the os calcis.

The wound should be carefully washed out to remove any fragments of bone that may have been left, and subsequently stitched; the tendon of the peroneus longus, if divided, being stitched. The foot should then be dressed with proper dressings and fixed in an overcor-

rected position by plaster bandages according to the ordinary rules in osteotomy.

Whether this operation should be done in connection with an osteotomy of the neck of the astragalus, and with an open incision at the same sitting, is a matter of judgment in each case.

Imperfect results are due to neglect of thorough asepsis, failure to remove a sufficient amount of bone, failure to remove it in such a direction as to cure the deformity, and lack of care in placing the foot in an overcorrected position after operation.

While the plaster is hardening the cuboid is pressed upward and outward, and the front of the foot pressed outward and upward, counter-

FIG. 492.—Case of Bad Relapsed Congenital Club-foot in a Woman of Thirty-four, Corrected by Force with the use of a Wrench. Photograph taken three months after correction, showing cicatrix of the tear of the skin caused by correction. (See Fig. 491.)

pressure being applied on the astragalus on the outer and upper side, and the os calcis twisted into its normal position.

Treatment can be carried out with a plaster-of-Paris bandage until the foot is thoroughly healed, and also until locomotion has been reestablished. After this the use of the club-foot shoe is advisable for at least some months.

RELAPSES.—No error is greater than a common one, namely, that tenotomy alone is sufficient to correct club-foot. In fact, tenotomy is only the beginning of a course of treatment. If the foot is rectified and held in place for a month, it is supposed by some surgeons that a cure has been effected. But such is by no means the case.

Moreover, it must always be borne in mind that relapses will *invariably occur* unless the distortion is overcorrected, and little reliance can be placed on the curative effect of time. Efforts at correction should be continued until the foot can be easily abducted beyond the median line, and while slightly abducted, can be flexed so that the dorsum of the foot shall form less than a right angle with the leg, the sole of the foot being flat, and there being no twist in the front of the foot. After this the correction appliance can be gradually omitted while manipulation of the foot is still carried on, and the case should be kept under observation.

Relapses occur in a certain number of cases simply from the carelessness of the parents, who are not aware of the necessity of retaining the corrected foot in the proper position for a long time. In such cases a second operation is advisable.

Relapses in older children are due to incomplete correction, either from a lack of thoroughness or from the existence of an unusual amount of distortion of the astragalus or os calcis not suspected, and demanding osteotomy, or from too early removal of the fixation or retention appliance.

In some instances of resistant club-foot it is found difficult, in correcting the foot, completely to overcorrect the equinus deformity, and to enable the foot to be brought to within a right angle with the leg. If this is not done, inconvenience is felt by the patient in taking a long step, and the foot is turned in to facilitate this. The smaller the foot the greater this danger. If this is not corrected, it may, in some instances, seriously interfere with the excellence of the result.

It should always be borne in mind that a distortion in the neck of the astragalus or in the head of the os calcis exists, even in infantile club-foot, and that the feet are not permanently corrected until the alteration of the facets into a normal position has taken place. This is independent of bringing the foot into a normal position, and demands fixation in an overcorrected position for some time. In some cases this is more needed than in others, probably because the alterations of the facets of the astragalus are in some instances slight.

Too great overcorrection of the deformity and the development of a splay-foot have sometimes resulted from overzealous treatment. The danger is, however, not great; and instances are rare, and are to be overcome by the treatment for a valgus foot.

Inversion of the foot, after cure of the club-foot, may in a few instances be observed from imperfect strength of the outward rotatory muscles at the hip. This, however, causes but little disfigurement, the inversion usually being slight, and correcting itself by the normal development of the muscles. A marked toeing-in of the foot in running persists a long time in some instances in which the foot is entirely cor-

rected and the walking is normal. It disappears with the increase of muscular strength. In such cases the ordinary Taylor shoe should be carried up to the hip by means of an upright on the outside of the leg and a posterior arm carried back from the level of the trochanter, as in the knock-knee splint. By tightening this, eversion is secured.

A relaxed state of the knee-joint causing inversion of the tibia is not uncommon in infantile club-foot; it usually corrects itself in the development of the child after correction of the foot. In rare instances, however, it may persist, requiring the longer use of a walking appliance.

The muscles retarded in club-feet by disuse need development before a complete cure is effected. Ordinarily the muscles develop of themselves after complete correction, if the limbs are actively used. In some cases the development is slow and massage and electricity are advisable.

Generalization as to Treatment.—The literature of the treatment of club-foot is too often that of unvarying success. It is sometimes as brilliant as an advertising sheet, and yet in practice there is no lack of half-cured or relapsed cases—sufficient evidence that methods of cure are not universally understood.

Surgeons differ somewhat in regard to the method of treatment of club-foot, but the following statements are regarded by the writers as worthy of acceptance:

First.—It is possible to correct completely infantile cases of congenital club-feet without the help of any operative interference, even tenotomy.

Second.—Tenotomy, however, even in infants is of assistance, and in older cases is in almost all instances necessary for a perfect cure. Tenotomy properly done is not followed by any unfavorable results to the muscles.

Third.—Certain resistant cases can be corrected and cured without operation upon the bone, but in such cases considerable force must be used.

Fourth.—In resistant cases, however, when there is deformity of the bone, osteotomy or a wedge-shaped resection of the astragalus or os calcis is necessary.

Fifth.—Congenital club-foot is a thoroughly curable deformity, provided the pathological conditions existing are thoroughly understood, and the resisting structures overcome.

Sixth.—For cure, overcorrection of the deformity is necessary and retention in an overcorrected position until the normal relation of the parts has been established.

Seventh.—The best retention appliance is one which interferes with the normal motion the least without permitting the distorted position of the foot.

Acquired Club-Foot—Paralytic Deformity.

The most common form of acquired talipes equino-varus is that following infantile paralysis which is described in another chapter.

The prognosis of paralytic club-foot is necessarily more unfavorable than that of the congenital form, although the distortion is more readily corrected; it is impossible to restore the affected muscles to a normal condition, and the prolonged use of some form of appliance may be necessary. In some instances, however, after thorough correction and retention for a while in a corrected position, if the foot is of sufficient size, relapse does not take place, or does so only in a partial degree, and a useful and but slightly distorted foot remains.

The correction of paralytic club-foot is to be conducted on the same principles as that of the congenital type. Correction is, however, much less difficult, as osseous changes are present only in the old severe and neglected cases.

Tenotomy of the contracted and healthy muscles can be done as in congenital cases, though overcorrection after tenotomy is to be avoided. Immediate correction and fixation in a corrected position are to be used after tenotomy as in the congenital form.

Tendon transferrence and arthrodesis as applied to this affection are discussed under infantile paralysis.

The walking appliance to be used in paralytic cases is in general the same as that which has been described in congenital cases.

TALIPES EQUINUS.

(Pes equinus, Horse heel, Pied bot equin, Pferdefuss, and Spitzfuss.)

Talipes equinus is the name given to a condition in which the foot is held in a position of plantar flexion and cannot be dorsally flexed to the normal extent (twenty degrees beyond a right angle).

Varieties.—Talipes equinus may be congenital or acquired. Congenital equinus is an uncommon deformity, constituting about five per cent of all cases of equinus. In 1,660 congenital deformities of the foot there were 40 cases of equinus. Its origin is no more clear than that of other similar congenital deformities. The congenital form of the deformity is generally not severe.

Acquired Talipes Equinus.

In the acquired forms all degrees of deformity are met, from the slight condition in which the foot cannot be flexed dorsally beyond a right angle with the leg, to one in which the foot and leg form practically a straight line.

Etiology.—The causes of acquired talipes equinus are as follows:

1. Infantile paralysis of the anterior muscles of the leg.

2. Cerebral (spastic) paralysis, hemiplegia, pseudo-hypertrophic paralysis, neuritis, and similar affections causing either loss of power in the anterior muscles of the leg or an overbalancing of these muscles by the contraction of the posterior group.

3. Shortening of the leg after joint disease or fracture may lead to

FIG. 493.—Talipes Equinus of Marked Degree. This represents the weight-bearing position.

FIG. 494.—Talipes Equinus of Left Foot Resulting from Paralysis.

an adaptive talipes equinus which serves to make the legs of equal length for walking.

4. Talipes equinus may be a symptom or result of disease of the ankle-joint.

5. Long confinement to bed may cause talipes equinus, which is merely the result of the long-continued plantar flexion of the foot.

6. Fractures may result in talipes equinus either from injury to the ankle-joint or from fixation during repair in a plantar-flexed position.

7. Hysteria may be a cause.

8. The contraction caused by posterior cicatrices or the loss of power due to division or injury of the anterior muscles and tendons of the leg may cause the deformity.

Pathology.—The structural changes in talipes equinus are slight. In a large number there is simply a shortening in the Achilles tendon or muscles, with a consequent alteration in the shape or relation of the bones and soft tissues of the foot. Some cases, however, are due less to the raising of the calcaneum than to a depression of the head of the astragalus, which may be depressed nearly in a vertical line, and the arch of the foot increased by a strong flexion at the medio-tarsal joint.

Symptoms.—The deformity in its slighter degrees is not particularly disabling. In its severer grades it is the cause of a severe limp and at times of much discomfort. A slight degree of the affection may be enough to cause a limp in walking, as in carrying the leg back at the end of the step the foot should be bent to more than a right angle. Corns and calluses of a severe grade are frequently found on the sole at the front of the foot. They may be a source of severe discomfort. In cases of moderate severity the weight of the body is borne on the distal end of the metatarsals in walking, the toes being hyperextended. In the severest forms of all the foot is bent on itself, so that the sole is directed backward and locomotion takes place on the dorsal surface of the metatarsus and toes. The arch of the foot is generally higher than the normal, and the condition which will be described as pes cavus may coexist with the equinus.

In the severer forms there is a marked projection on the dorsum of the foot formed at the site of the calcaneo-cuboid and astragalo-scaphoid articulations. As locomotion occurs only on the ball of the foot, this part becomes abnormally wide, and in time the plantar fascia contracts and resists the reduction of the malposition.

The spastic form is most commonly met in spastic paralysis or after hemiplegia. As this is due to the contraction of the muscles of the tendo Achillis, the position of the foot in this differs from that following paralysis. The heel, in the spasmodic form, is drawn upward and the whole foot depressed in consequence. There is, therefore, less tendency to the formation of an angle in the medio-tarsal or tarso-metatarsal joints.

The form often met in shortened limbs, as after recovering from hip disease, fracture, etc., is the result of the maintenance of the foot for a long time in a partially extended position, in the act of walking and standing. In these cases it is a compensatory arrangement, inasmuch as it tends to keep the pelvis level, and not to be regarded as objectionable except in its appearance.

The detection of talipes equinus is a simple matter. The normal

foot should be capable of flexion about twenty degrees beyond a right angle, and any cause which restricts this flexion is a degree of talipes equinus.

Treatment.—The division of the tendo Achillis will relieve the deformity in all cases except those in which bony deformity exists at the ankle, as in the cases following fracture and tuberculosis of the ankle-joint. In such cases or in extremely severe instances of deformity from other causes, a wedge-shaped osteotomy of the tarsus might be required for rectification, but this would be unusual.

The deformity should be at once corrected after tenotomy and a plaster-of-Paris bandage applied. If a retention appliance is required after operation, a modification of the club-foot shoe, with the ankle-joint arranged to stop extension at a right angle, will be found to be effectual and simple. Or a simple foot-piece joined to two uprights and a posterior band may be used, which is jointed in the same way at the ankle. This prevents the foot from rolling in or out and thus makes the act of walking a force to pull upon the tendo Achillis at each step (Chapter XXI., **28**).

Acquired talipes equinus is in most cases due to anterior poliomyelitis, and the treatment of that form has been discussed there. In cases due to ankylosis of the ankle-joint or to severe acquired distortion of the bone from prolonged neglect, a wedge-shaped osteotomy might be necessary.

TALIPES CALCANEUS.

(Pes calcaneus, Pied bot calcanéen, and Hackenfuss.)

Talipes calcaneus is the name applied to a condition in which the foot is held in a position of dorsal flexion.

Varieties.—The deformity may be congenital or acquired.

It is a comparatively rare congenital deformity, about two-thirds as common as congenital equinus (28 cases in 1,660 cases of congenital deformity of the foot). The hollow in the sole of the foot so often present in the acquired variety is likely to be absent in the congenital. It may be noticed only as a slight downward prominence of the heel or it may be so se ere that the dorsum of the foot may be laid against the anterior surface of the tibia. Its etiology is practically the same as that of the other congenital deformities.

Acquired talipes calcaneus is less common than acquired equinus. It presents the same characteristics as the congenital form, except that an increased hollowness in the arch of the foot is likely to coexist, in which case the deformity may be spoken of as talipes calcaneo-cavus. The cause of the acquired deformity is in most cases paralysis of the muscles of the calf of the leg from anterior poliomyelitis. It may occur in chronic disease of the ankle as a symptom of muscular irritability.

It exists sometimes in hysteria, and it may result from rupture or division of the posterior muscles of the leg, from cicatrices in the front of the ankle, and from ankylosis of the ankle-joint in a faulty position.

The pathology of the affection is manifested by the changes incident to the maintenance and use of the foot in this abnormal position. Stretching of ligaments and muscles are found on one side, with shortening on the other and changed relations between the bones, resulting perhaps in the development of new articular facets.

Symptoms.—The patient walks upon the heel and the gait is inelastic, because the spring of the foot is absent and the patient walks bearing the whole weight on the os calcis. The diagnosis presents no difficulty, except that it must be remembered that the association of the deformity with both valgus and cavus is frequent.

FIG. 495.—Talipes Calcaneus.

Treatment.—In congenital cases the foot should be daily manipulated by the parents into a position of plantar flexion. As soon as the anterior muscles are stretched, it is advisable to put the foot up in a position of plantar flexion, to bring about adaptive shortening of the posterior muscles. In the severer cases the application of a series of corrective plaster bandages holding the foot in plantar flexion may be necessary. Tenotomy of the anterior tendons is rarely required. When the foot can be plantar-flexed to the normal amount, a retention shoe preventing dorsal flexion may be applied, but in slight cases this is not necessary (Chapter XXI., **29**).

TALIPES VALGUS.

Talipes valgus is the name given to a condition which is not in all cases to be clearly differentiated from what has been described as flat-

foot. Talipes valgus may be congenital or acquired. As a *congenital* deformity it is one of the more common of the congenital deformities of the foot. In 1,660 cases of congenital deformity of the foot there were 123 of congenital valgus. The bones in congenital flat-foot even in severe cases show but little alteration in shape. The astragalus is turned obliquely to one side and downward, and the angle of the articulation faces more to the side than is normal. The end of the os calcis may be slightly raised. The scaphoid is turned to the outer side and is rotated on its central axis, so that the outer side is slightly raised and the inner side is lowered—the arch of the foot is obliterated and the inner border is often convex rather than concave.

FIG. 496.—Moderate Degree of Talipes Valgus, Right Foot.

FIG. 497.—Talipes Varus, Right Foot.

It may exist by itself or in connection with other defects of the bones of the foot or leg. It may exist alone or associated with calcaneus or equinus. The deformity of congenital valgus is likely to be extreme and the sole of the foot may present a downward convexity. The three elements mentioned in flat-foot—abduction of the front of the foot, eversion of the sole, and lowering of the arch—may be fully developed. The changes of the bones do not differ essentially from those described in acquired flat-foot. The deformity may

be spoken of as congenital flat-foot, from which it is not to be distinguished.

Acquired Talipes Valgus is a condition characterized by eversion of the sole of the foot or abduction of the front of the foot in relation to its long axis, or by both. It differs from acquired flat-foot in the absence of a distinct dropping of the arch of the foot. This distinction is not to be made in all cases nor is it of great importance, but, in general, cases presenting the two first conditions mentioned are to be classed as valgus, and cases with the dropping of the arch also as flat-foot. The most common cause of acquired talipes valgus is anterior poliomyelitis. It also occurs in hysteria, following inflammation of the ankle-joint, and in certain cases of spasm of the peroneal muscles. The symptoms, as contrasted with those of flat-foot, are generally characterized by less pain, and the modification in the gait produced by the abnormal position is in general more prominent than pain.

The treatment of the condition consists in the application of an apparatus (Chapter XXI., **31**) to correct the rolling inward of the ankle, combined generally with some support to the arch of the foot. In the milder cases the application of a flat-foot plate would be sufficient treatment.

TALIPES VARUS.

Talipes varus is the name given to a condition in which the sole of the foot is turned inward. Simple talipes varus occurred eighty-five times in sixteen hundred and sixty congenital deformities of the foot. In its congenital form the deformity is apparently an incomplete variety of ordinary club-foot in which the element of equinus is not marked. In the acquired form it results from infantile paralysis and is at times seen as the result of severe knock-knee. As associated with talipes equinus it is the commonest of congenital deformities of the foot.

Treatment.—In the congenital form the treatment is practically the same as that of equino-varus, except that it may not be necessary to cut the tendo Achillis. In the acquired form retentive apparatus is useful, preventing eversion of the foot (Chapter XXI., **30**).

TALIPES CAVUS.

(Hollow foot, Pes cavus, Pes arcuatus or excavatus, Pied bot talus, Pied creux, Hohlfuss.)

Talipes cavus is the name given to a condition in which the arch of the foot is increased and the anterior part of the foot is approximated to the heel. It is not necessarily associated with any other deformity, but may occur in connection with talipes equinus, calcaneus, valgus or

varus. It is rarely congenital in its severe forms,[1] but a markedly high arch to the foot may be an inherited peculiarity sometimes sufficiently marked to justify classing it as pathological. In the acquired form it exists in most cases as the result of anterior poliomyelitis, and is also to be classed as a shoe deformity. The pathological changes show nothing besides the effects of a continued malposition of the bones. The deformity varies more or less in degree. The most marked form is to be found in the foot of the Chinese lady of high rank, in which the heel and front of the foot are approximated by bandaging in early youth, and a degree of pes cavus is induced which does not exist except under these highly artificial conditions. From this ex-

FIG. 498.—Pes Cavus with an Element of Calcaneus.

treme grade all degrees of the affection are seen, the slightest being an increased elevation of the arch not accompanied by symptoms, in which the foot rests upon the ground in standing, touching only on the heel and ball of the foot. It is less disabling than pes calcaneus, and is frequently associated with the other deformities mentioned. The two types commonly seen are, first, those resulting from anterior poliomyelitis, in which a paralysis more or less extensive has involved the foot and leg. In a second form, generally milder in grade, it apparently develops as a shoe deformity in middle childhood, and appears to be the result of wearing too short a shoe or of a shoe narrower than the front

[1] Redard: "Chir. orth.," p. 839.

of the foot; the front of the foot being held back by the front of the boot, the tendency in weight-bearing is to approximate the heel and the toe, and in this way to approximate the front of the foot to the heel. In the slightest grade it apparently forms one of the varieties of the condition described as *contracted foot*. The plantar fascia is contracted and bands may be felt under the skin. The symptoms in the slighter varieties are those of a sprain of the arch of the foot and the muscles of the leg, owing to insecure balance of the foot in standing. Corns and callosities may develop in the front of the foot; the elasticity of the gait is impaired.

The treatment of the slighter forms, in which the symptoms are due to the imperfect balance of the foot, consists in the use of a boot with sufficient room in front and of proper length, which is provided with a high arch or artificially high shank, to give the foot a correct bearing surface and to contribute to its stability. If any element of equinus coexist, the gastrocnemius muscle must be stretched.[1] In cases of average severity in young children a flat steel plate running the length of the boot may be inserted between the layers of the sole, and the dorsum of the foot strapped down to it by a strap running over the top of the foot and fastening to the plate. This will tend to stretch the contracted tissues in walking. Operation is required in the severer cases. The plantar fascia is thoroughly divided by a subcutaneous tenotomy and the foot put up in a plaster bandage which should flatten the arch of the foot as much as possible. When walking is begun, which should be as early as possible after operation, the steel sole plate and strap described above should be adjusted to the shoe.

CLUB-HAND.

In German the distortion is known as *Klumphand*, and in French as *main bote*.

Congenital club-hand is a rare condition, which is in many cases analogous to congenital club-foot. The name is applied to a deviation of the hand, at the wrist, from the line of the forearm; this deviation is almost always in the direction of flexion.

It occurs at times without malformation of bones, in which cases there may be also stiffness of the shoulder- and elbow-joints of the affected arms, with imperfect development of the muscles. At other times there is associated with the club-hand an absence or defective development of the radius or ulna, often associated with other malformations. With the defective development of the bones of the forearm are likely to be associated muscular defects and anomalies.

Varieties.—The modern classification of the distortion is to speak of the cases as palmar and dorsal club-hand, as the deformity is toward

[1] Shaffer: N. Y. Med. Jour., March 5th, 1887.

flexion or extension; or as radial, and ulnar or cubital, as the deviation is inward or outward at the wrist. Mixed forms are the most common, and are spoken of as radio-palmar, etc. The dorsal forms are rare. The bones of the arm may be normal, but more commonly they are deformed, or the radius may be wanting wholly or in part. The carpus may be normal, or incompletely developed, or almost entirely wanting. When the radius is deficient, the lower end of the ulna is enlarged to

FIG. 499.—Club-hand Due to Congenital Absence of Radius. (Sayre.)

articulate with the carpus. A variety of anomalies of the muscles, vessels, and nerves may occur.

Etiology.—No satisfactory etiological cause can be assigned for the occurrence of club-hand, beyond the usual explanations urged to account for congenital deformities in general.

Symptoms.—In looking at the palmar varieties of club-hand it is seen that the wrist is sharply flexed, and that perhaps the lower end of the radius may be covered by the skin and traversed by the extensor tendons, while the carpus articulates with the under surface of the radius. The forearm is wasted, and if the radius is absent it appears to be very slender indeed. The hand possesses a certain degree of mobility at the wrist, and when it is partly replaced the flexor tendons can be felt to be rendered tense, and stand out under the skin.

The **diagnosis** is evident, and any pathological process which is accompanied by this malposition is classified as club-hand.

Treatment.—In the mildest cases, particularly if the bony structure is normal, treatment should consist of manipulation to stretch the contracted tissues and retention in the correct position by means of a splint.

Tenotomy is to be done only if reposition is impossible without it. After retention in the proper position for a sufficient time, massage and muscle training should be begun.

Where bony defects are present and the case is not to be rectified by the measures described, some operation on the bone may be performed. R. H. Sayre[1] performed an osteotomy of the ulna to correct its curve, and later removed two of the carpal bones and the styloid process of the ulna and inserted the end of the ulna into the gap in the carpus. Thompson[2] removed a wedge from the lower part of the ulna. McCurdy divided the ulna across and sutured the distal end to the semilunar bone.[3] Bardenheuer[4] has split the lower end of the ulna longitudinally and implanted the carpus between the two parts of the ulna separated.

The reported results of these operations have been favorable, but it must be evident that the joint under these conditions must be an imperfect one.[5]

[1] Trans. Am. Orth. Assn., vol. vi., p. 208.
[2] *Ibid.*, vol. ix., p. 165.
[3] *Ibid.*, vol. viii., p. 8.
[4] Verhandlung der deutschen Gesellschaft f. Chir.. 1894.
[5] Kirmisson: "Mal. Clin. d'Origine Congén," 1898.

CHAPTER XX.

FLAT-FOOT AND OTHER DEFORMITIES OF THE FOOT.

Flat-foot (Definition.—Pathology.—Varieties.—Causation.—Frequency.—Symptoms.—Diagnosis.—Prognosis.—Treatment).—Anterior metatarsalgia.—Hallux valgus.—Hallux varus.—Hallux rigidus.—Hammer toe.—Clawed toes.—Painful heel.—Post-calcaneal bursitis.—Synovitis of tendo Achillis.—Exostoses.

FLAT-FOOT.

Definition.—The term "flat-foot" is applied to a deformity usually of a static type—that is, one due to superimposed weight. This deform-

FIG. 500.—Print of Child's Foot in Moccasin, Showing Weight-bearing Portion of Foot.

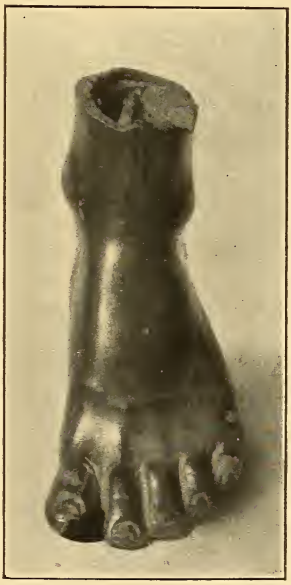


FIG. 501.—Foot of Japanese Bronze. (Boston Art Museum.)

ity resembles in many respects talipes valgus, and has been considered by many writers a variety of that distortion. There is, however, sufficient difference to warrant a consideration of flat-foot by itself.

The abnormality of flat-foot is best understood by a comparison with the normal standard.

Normal Foot.—If the foot of a young infant is examined it will be

Fig. 502.—Feet of Charioteer.

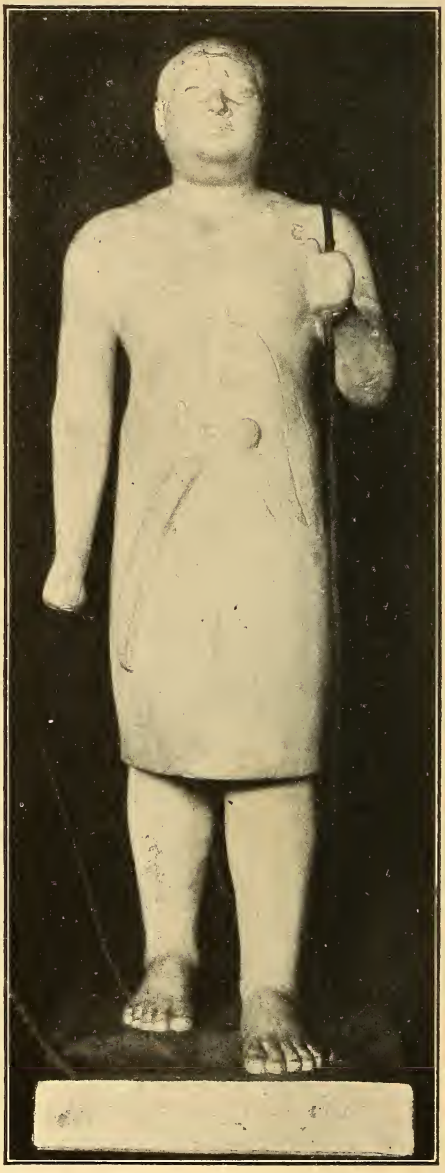


Fig. 503.—Egyptian Statue.

seen that there is muscular power in the movement of all of the toes. The great toe can voluntarily be drawn to the inner side, and the fifth

toe can be drawn to the outer side by voluntary muscular exertion. The toes can be flexed readily. The second toe is, when stretched to its full length, frequently longer than the first. The third is of the same length as the first, the fourth is somewhat shorter, and the fifth, though shorter, is but slightly so. None of the toes remains permanently curled, though when in a relaxed condition the terminal phalanx drops somewhat and the smaller toes curl. A separation between the first and second toe is normal. When the muscles are active the great toe is drawn to the inner side frequently. The line of the extremities of the toes presents a gradual curve with the greatest forward convexity at the tip of the second toe. The line of the inner edge of the foot is always straight except when there is contraction of the muscles.

FIG. 504.—Left Foot of Child Eighteen Months Old. (Dane.)

If the undistorted adult foot which has never worn shoes be examined, it will be found to present many of the characteristics of the infant's foot, but there is greater muscular power in the toes and foot and relatively less fatty tissue. The flexibility of the front of the foot is great, and can be increased by training, especially in the power of separating the great toe from the next, which is utilized as an aid in prehensibility.

If in comparison the foot of an adult who has always worn shoes is studied, a loss of flexibility in the movements of the toes, often some distortion of the front of the foot, and an impairment of muscular power of the muscles of the foot are seen. The effect of this impairment is to favor the development of the deformity generally known as flat-foot.

Pathology.—In light cases of flat-foot the anatomical changes show very few alterations in the shape of the bones. There is simply an altered relative position.[1]

[1] "Statik und Mechanik des menschl. Fusses," Zeit. f. orth. Chir., 1894, iii., 243.—R. W. Lovett and F. J. Cotton: Trans. Am. Orth. Assn., vol. xi.—Petersen: Arch. f. Orth. (abst.), i., 3.—Riedinger: Centralbl. f. Chir., 1897, No. 15.—v. Meyer: "Ursache und Mechanismus der Entstehung des erworbenen Plattfusses," Jena, 1883.

The nature of the mechanism of the deformity will be better understood if the normal action of the foot in standing and walking is borne

FIG. 505.—Savage Feet.

in mind. If an individual with normal feet stands with both feet placed together and pointed forward, the weight in each foot falls upon a point midway between the outer and inner edge, passing through the

ankle and astragalus and being distributed to the rest of the foot. If, now, the superimposed weight is made excessive by having the individual stand upon one foot, the body inclines to that side to preserve the

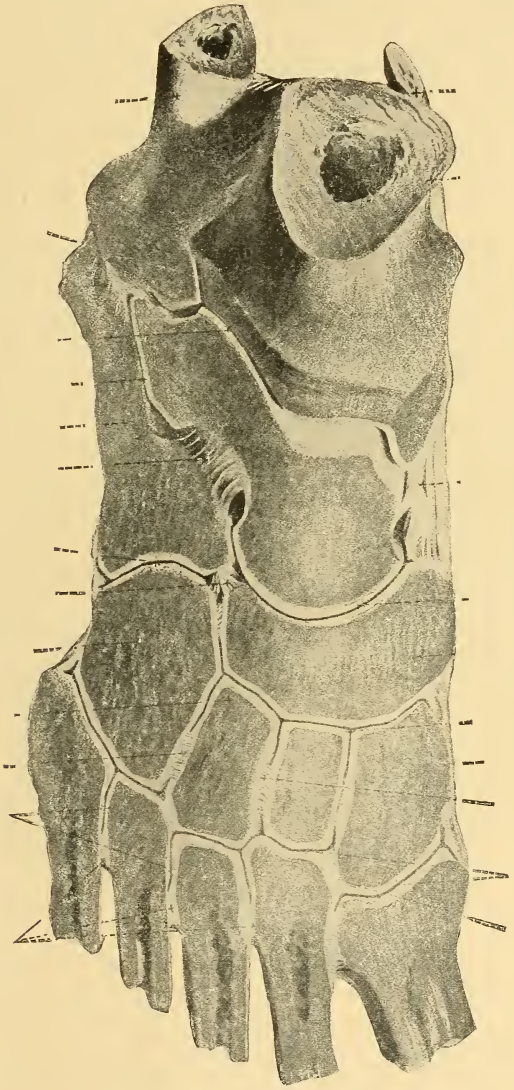


FIG. 506.—Longitudinal Section of Foot. (Fick.)

balance and to prevent side strain. When the weight upon the foot comes in such a way that it cannot be brought directly over the middle of the foot, a movement takes place whereby the side strain is diminished. This represents *the position of muscular strength* when exposed to the strain of excessive superimposed weight. In this movement the

astragalus and ankle are pulled sideways to the outer side of the foot, the ball of the foot and the heel being placed firmly on the ground and the astragalus being held firmly from lateral motion by the tibia and the fibula. This motion, which is made possible by the many articulations of the foot, occurs in the midtarsal joint chiefly. The scaphoid, the inner cuneiform, and the posterior end of the first metatarsal are

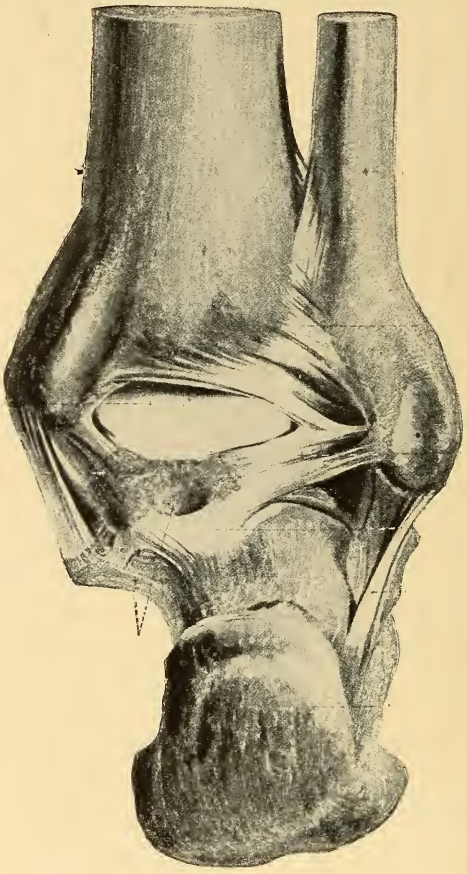


FIG. 507.—Posterior View of Foot, Showing Ligamentous Support and its Weakness to Strain Inward. (Fick.)

brought upward and to the outer side, the great toe and the head of the first metatarsal are pressed firmly on the ground, and the os calcis and the cuboid move with the astragalus.

In contrast with this movement of strength and muscular support must now be considered *the position of relaxation* and ineffectual support. When the patient is standing, if the muscles moving the great toe and the head of the first metatarsal or those regulating the outward and upward movement of the inner side of the scaphoid are weak or

inefficient or do not act with strength, the midtarsus drops to the inside when superimposed weight falls upon it, and the movement is the reverse of that described above. The astragalus rotates inward; the scaphoid, the cuneiform, and the proximal end of the first metatarsal move downward and inward; and the front end of the os calcis and the cuboid follow the astragalus to the side. This involves a twisting of the whole limb, which rotates at the hip-joint. The astragalus moving with the leg on the bones of the foot, the inner malleolus will in consequence be seen to move downward, inward, and backward. Up to a certain limit this movement occurs in relatively normal feet, but be-

FIG. 508.—Print of Arab Foot.

FIG. 509.—Plaster Cast of Dental Wax Foot Impression in Sand, Showing Weight-bearing Portions of Foot.

yond this what must be regarded as a pathological condition is reached, attended by symptoms of pain and disability, and is the first step in the formation of flat-foot.

The deformity, strictly speaking, is not a flattening of the foot, but consists of an exaggerated midtarsal drop and twist, occurring, as has been said, normally under certain conditions. The deformity is a combination of inward rolling and dropping to the inside of the middle of the foot, with an outward deviation of the front of the foot. Normally in the standing position, if the patella faces straight to the front, the foot should be directed also straight ahead; but in flat-foot the front of the foot turns to the outside when the leg is placed with the patella

and ankle squarely to the front. The deformity has for this reason been termed pronated foot, as the deformity somewhat resembles pronation. It is also called weak or weakened foot.

FIG. 510.—Casts of Civilized and of Savage Feet.

There is necessarily a variation in the relative prominence of the different factors of the deformity in individual feet: 1. The inward

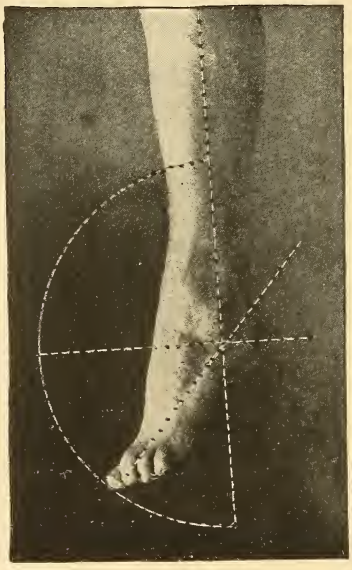


FIG. 511.—Voluntary Plantar Flexion (Normal). (Whitman.)

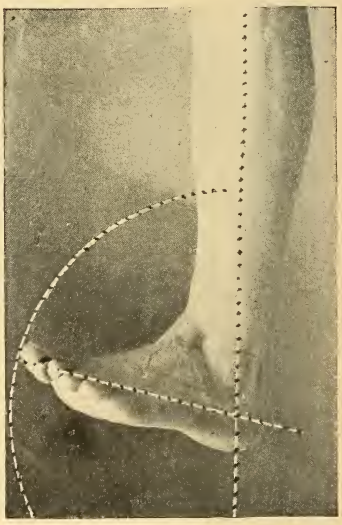


FIG. 512.—Voluntary Dorsal Flexion (Normal). (Whitman.)

movement of the midtarsus, "the dropping in" of the foot, may be the characteristic of some cases. 2. The dropping down of the arch may

be the most prominent feature in others. 3. The abduction of the front of the foot, resulting in a change of the angle between the front of the foot and the axis of the heel, may characterize still other cases. And these three factors may be present in varying proportions and

FIG. 513.—Weakened Foot without Breaking Down of Arch.

relations. The recognition of the relative prominence of these elements is of much importance in treatment.

Alterations in the shape of the bones are noted, in severe cases the

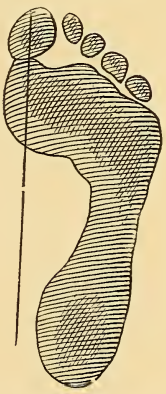


FIG. 514.—Meyer's Line in Average Foot.

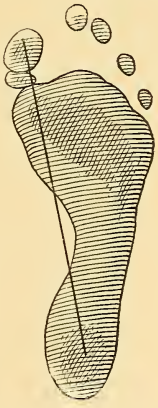


FIG. 515.—Meyer's Line in Normal Foot.

external malleolus being at times somewhat flattened and rounded. The chief distortion in the bones occurs in the astragalus, os calcis, scaphoid, and cuboid. In extreme cases the astragalus has dropped from above to the inside of the os calcis, the latter being rolled to the

inside with a deviation of its forward end to the inside. The front of the foot is turned outward, the scaphoid and cuboid being practically

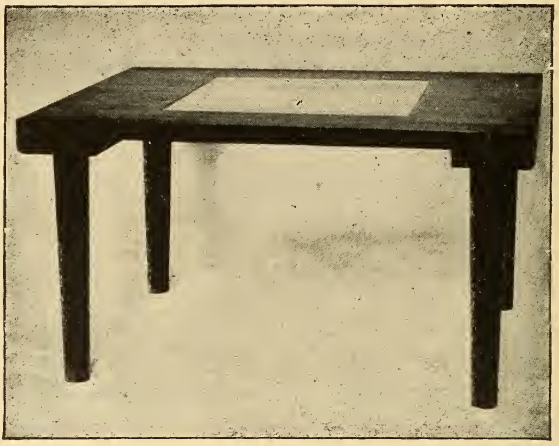


FIG. 516.—Table with Glass Top for Examining Feet.

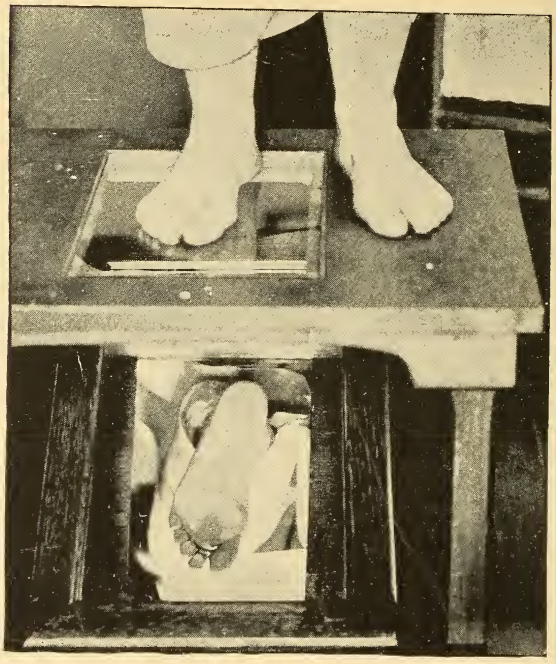


FIG. 517.—Glass Table for Examining, in Use with Mirror.

dislocated. At the outer side the cuboid may be displaced upward. Changes in the direction of the metatarsus and of the phalanges are found. Exostoses are frequently developed.

There is a loss of the normal play of the bones in the tarsal articu-

lations from loss of elasticity of the ligaments, and changes in the shape of the bones result from abnormal pressure.

The muscles are changed in their strength, the tibialis being weakened and the peronei contracted.

The plantar ligaments are stretched and displaced, and those bearing strain are thickened.

Varieties.—As has been already mentioned, talipes valgus resembles flat-foot, and they are often classed together. For clinical rea-

FIG. 518.—Type of Tracing Described as Normal.

sons it is more convenient to consider the subjects separately. The same is also true of congenital valgus, sometimes called congenital flat-foot.

Infants were thought to be flat-footed, but this has been shown to be apparent rather than real.[1]

Causation.—In general terms it may be said that the deformity is caused by a disproportion between the weight to be borne and the muscular power which bears it. Among the determining causes may be mentioned:

1. Boots of improper shape or size.

2. Weakness or insufficiency of the muscles, resulting from ill health and especially following confinement.

[1] Dane: Trans. Am. Orthop Assn, 1898.—Spitzy: Zeitschrift f. orth. Chir., xii., 4, 777.

3. Prolonged standing.
4. Rapid growth.
5. Rapid increase in weight.
6. Accident or disease, causing disuse of limb and muscular weakness.

FIG. 519.—Flat-foot Occurring in a Young Rhachitic Child.

7. Excessive weight-bearing, as in the case of professional strong men and jumpers.

8. A shortened condition of the gastrocnemius muscle, as described

FIG. 520.—Outline Drawing (from Photograph), Showing Inward Excursion of Internal Malleolus in Pronation.

FIG. 521.—Composite Photograph, Showing Excursion of Malleolus and Arch with and without Weight-bearing. (Dane.)

by Shaffer. Unless dorsal flexion of the foot beyond a right angle is possible, it is difficult for a person to complete the step with the leg straight behind him and the foot pointing forward. Eversion of the

foot is necessary, and a completion of the step by rolling over on to the inner side of the foot.

9. Rickets, distorting the bones of the foot.
10. Infantile paralysis.
11. Spastic paralysis or other disturbances of muscular balance.
12. Trauma and inflammation.

The most common of traumatic causes is Pott's fracture, in which a deformity is the result of inefficient treatment or of a very severe and intractable fracture. As a result of ankle-joint disease accompanied by considerable destruction of tissue, one sometimes sees very marked flat-foot, which does not tend to grow worse, because there is generally firm ankylosis in the ankle; but the deformity may be severe. Acute arthritis, especially of gonorrhœal origin, is a not infrequent cause of flat-foot.

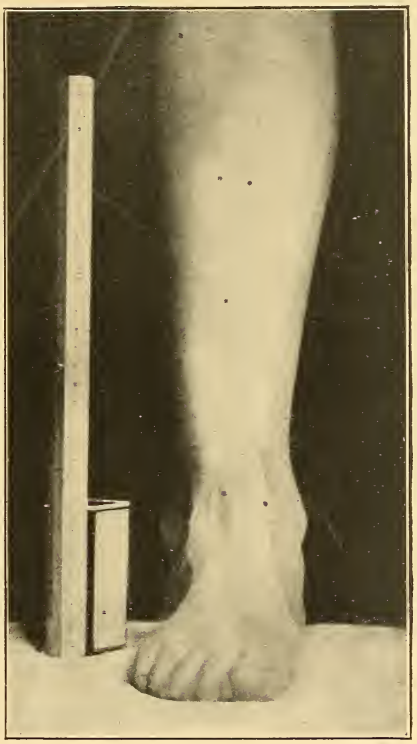


FIG. 522. — Composite Photograph, Showing Lateral Excursion of Lower Leg and Foot with and without Weight-bearing. (Dane.)

Causation.—Flat-foot has been mentioned as a race peculliarity, negroes and Jews being mentioned as especially afflicted; but facts do not warrant the statement, which has been found not to be true of the native negroes of Africa.[1]

Many of the barefooted races have been considered flat-footed simply because of the strong development of the muscles of the sole, careful examination showing excellent arches.

The most common cause is the weakening of the muscles of the foot by shoes. Shoes as worn by the leisure class or by the class that gain their livelihood (as is the rule in cities) by occupations which require standing rather than strong and vigorous walking, compress the front of the foot. This part of the foot, from compression and from resulting weakness, cannot adapt itself as greater weight is thrown upon the foot, and the medio-tarsal twisting takes place, which in the strong bare foot is prevented chiefly by the action of the tibial muscles

[1] Freiberg: Am. Journ. of Orth. Surgery, vol. i.

and by the muscles of the first metatarsal and its phalanges. People the front of whose feet has been compressed stand and walk with a greater angle of divergence of the axes of the feet, which increases the danger of the development of the deformity by bringing greater strain upon the inner side of the foot and favoring the inward rolling which frequently develops flat-foot. Flat-foot is not developed among moccasined savages who use their feet actively as hunters, using the muscles of the front of the foot freely.

Symptoms.—*Flat-foot* is a deformity characterized by a flattened appearance of the sole of the foot.

The deformity is also called splay-foot, pes planus, and spurious val-

FIG. 523.—Tracing of a "Flat-foot." No symptoms.

gus; in German, Plattfuss; and in French, pied plat. It is also sometimes called pes pronatus.

It can for convenience clinically be divided into two groups:

1. Flexible flat-foot or *weakened foot*, where little or no structural changes have taken place and the foot assumes the flattened position only when weight falls upon it.

2. *Rigid flat-foot* or flat-foot proper, in which the distortion is permanent, some structural change in ligament or bone having taken place.

In Blodgett's[1] series of one thousand cases the females predominated, and two-thirds of the cases were under forty years of age.

[1] W. E. Blodgett: Am. Journ. of Orth. Surgery, vol. ii., No. 2.

Deformity.—In the severer cases, instead of the normal arching upward of the inner border of the foot, this border is either less arched than normal or is in contact with the ground. The foot has the appearance of being not only broad but abnormally long. It is more or less everted, and in severe cases the head of the astragalus and the scaphoid tubercle form a marked bony prominence at the middle of the inner border of the foot. The internal malleolus is more prominent than normal and is thought by the patient to have enlarged. In the milder cases, which are often too slight properly to deserve the name flat-foot, there is the beginning of a similar process. This beginning abnormal-

Fig. 524.—Flat-foot of Moderate Degree.

ity of position, although sufficient to cause symptoms, may be so slight as to escape observation except on the closest inspection. There is a tendency of the inner malleolus to be more prominent, the foot is slightly everted, the weight is borne more on the inner border than is normal, and the arch of the foot may appear to be somewhat lower than normal. This condition might perhaps be better spoken of as a strained than as a flattened foot; from this condition to that of a completely flattened foot every degree is to be seen clinically. Marked flat-foot may be present without causing symptoms. It is not infrequently seen in athletes and occurs as a perfectly useful foot in a cer-

tain small proportion of persons. In such cases the foot is flexible; when structural changes have taken place in the ligaments, muscles, or bones, and stiffness is present, painful symptoms are generally seen.

Flat-foot is more frequently double than single, and as a rule the

FIG. 525.—Severe Double Flat-foot.

symptoms in one foot are more severe than those in the other. The symptoms are frequently worse in the foot showing the least deformity.

PAIN.—The first symptom complained of is a sense of discomfort in the feet after standing or walking. This may increase until pain of greater or less extent is present during and following use of the feet. In the milder cases pain ceases when the weight is removed, but as the condition becomes more advanced the pain not only becomes more severe, but continues after the use of the feet is stopped, and in the severer cases persists during part of the night. The severity of the pain may be greater than is to be expected from the amount of distortion. The pain is most frequent in the neighborhood of the scaphoid; it occurs also in the front of the foot, in the centre of the heel, behind the inner malleolus, and on the outer border of the foot. Pain is also complained of in connection with flat-foot in certain cases in the leg, knee, back, or hip.

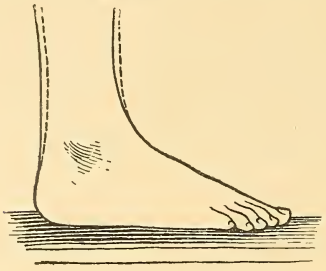


FIG. 526.—Outline Drawing (from Photograph) in Normal and Pronated Position, Showing Forward Excursion of Mark over External Malleolus in the Pronated Position.

TENDERNESS.—Tenderness is seen over points of ligamentous

strain; it occurs under the scaphoid, under the centre of the heel, behind the internal malleolus, at the outer border of the foot, and in the great toe-joint. It is rarely absent and may be found in one or more of these situations, according to the type of the distortion.

Muscular Spasm.—In very acute cases there may be irritability

Fig. 527.—Displacement of Little Toe. (H. L. Burrell.)

and contraction of the peroneal muscles holding the foot in the position of abduction; in this case there is apt to be tenderness over the origin of the peroneal muscles. Irritability of the gastrocnemius frequently

a *b*

Fig. 528.—*a*, Flat-foot; *b*, Flat-foot with Eversion. (Children's Hospital Report.)

exists, and tenosynovitis of the tibial and peroneal muscles is occasionally seen.

Stiffness.—Congestion of the foot and swelling of the foot and leg are frequent symptoms. Stiffness or loss of flexibility is a symptom which is gradually developed, and it involves at first and most promi-

nently the mediotarsal joint. The stiffness is such that the front of the foot cannot be adducted actively or passively as much as it normally should be. This is an important matter to recognize, as it prevents an assumption of a correct position by voluntary muscular effort until the proper flexibility is restored. There is also, especially in the later history of the case, some limitation in the plantar and dorsal flexion of the foot at the ankle-joint.

In severe flat-foot, owing to the change in the form of the bones, there is a limitation in the amount of motion at the ankle-joint. The normal amount of motion, which should be 80°, in flat-foot may be restricted to 30° or 40°.

Gait.—The gait becomes modified as the affection progresses and becomes in a measure characteristic. The feet are generally more everted than normal, and in painful cases it will be noted that in standing the patient deliberately throws the foot over, so that the weight is borne more upon the inner border than is normal. There is a lack of elasticity to the gait, and this is a symptom often complained of by the more intelligent patients, who find their feet stiff and clumsy. After the patient has been sitting for some time and on rising in the morning the feet are likely to be stiff and clumsy.

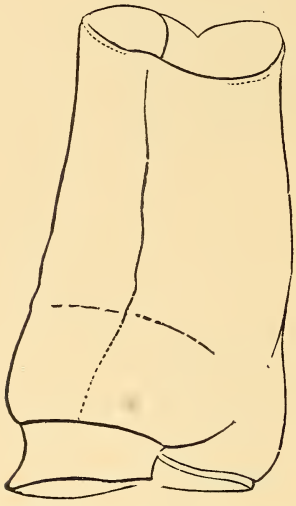


Fig. 529.—Boot for Left Foot Worn by Patient with Severe Flat-foot, Showing Characteristic "Treading Over" of Shoe.

Contracted Foot.—Mention should be made of a type of painful affection of the foot often seen in practice, in which the symptoms of muscular irritability and contraction predominate. It may be an accompaniment of mild flat-foot or it may exist in connection with a highly arched foot. Such feet cannot be dorsally flexed beyond a right angle, and perhaps motion may be restricted in other directions. Pain and irritability in walking may be noticed in the calves of the legs as well as in the arches of the feet, and even backache may be present. This variety of irritable and strained foot is probably one of the affections described as "contracted foot"[1] or "non-deforming club-foot."[2] It is apparently due to the strain and bad balance induced by wearing improper and ill-fitting shoes. It is most commonly seen in women of the upper classes.

[1] Lovett: Art. "Orthopedic Surgery," Park's "System," 2d ed.—Whitman: "Orth. Surgery," 2d ed., p. 699.

[2] Shaffer: N. Y. Med. Rec., May 23d, 1885; N. Y. Med. Journ., March 5th, 1887.

Symptoms in Children.—In young children the symptoms are somewhat modified. Pain is not a common symptom, and rigidity in the deformed position is rare. The amount of flattening is on the average greater than in adult cases when the child is in the standing posi-

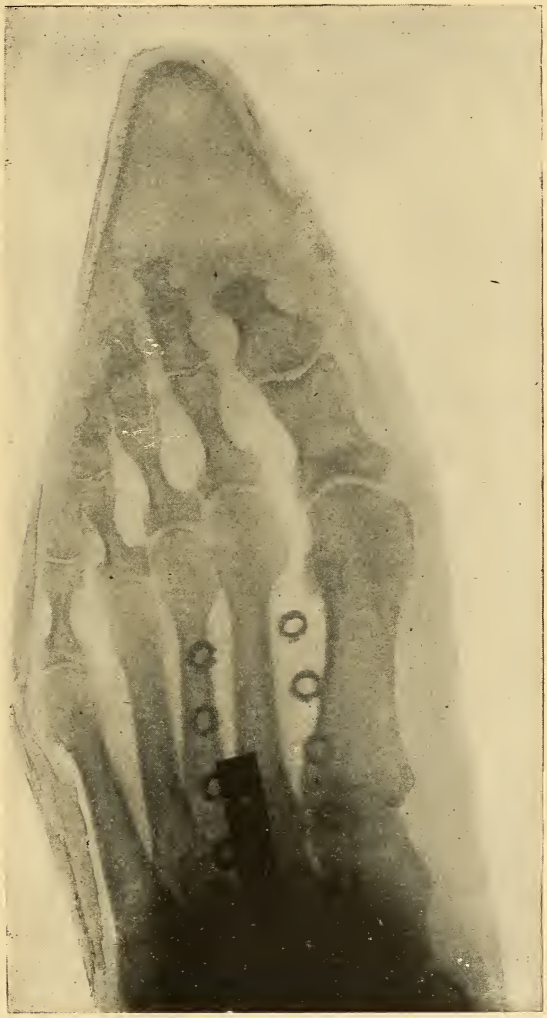


Fig. 530.—Radiograph Showing Compression of Left Foot by Boot.

tion. The child tires easily, is not steady in walking or light on the feet in movements requiring balance, and falls frequently. Associated with the flattened foot there is often to be found in young children an abnormal lateral mobility of the knee-joints.[1]

[1] Journ. Am. Med. Assn., April 18th, 1903.

Diagnosis.—The recognition of a static disturbance in the foot sufficient to give rise to pain is to be made partly from the history of the case, and partly from the examination of the foot. The characteristic symptoms have been already indicated.

For examination of the feet, the shoes and stockings should be re-

FIG. 531.—Radiograph Showing Right Foot Uncompressed by Boot.

moved and the patient should stand facing the surgeon upon the floor or upon a plate of glass with a mirror underneath.

The relation of the foot to the leg should be noted, whether the internal malleolus is unduly prominent and the foot rolled over on to its inner border. The height of the arch of the foot is of importance, and

any lowering of the inner border is significant. The rolling of the foot further on to its inner side or the lowering of the arch after the patient has stood for a minute indicates muscular insufficiency under weight-bearing.

If, in addition to its outline, the sole of the foot is inspected by means of the mirror, the normal foot will show an evenly distributed anæmic area, the weakened foot will bear more weight at its inner surfaces at the front and back of the foot, and will roll over further under the influence of muscular fatigue.

The impression of the weight-bearing foot is of interest, but not of great diagnostic value. In the tracing as ordinarily taken the non-weight-bearing position of the foot is recorded first and then the weight-bearing position, the two being superimposed. The abnormal and the

FIG. 532.—Normal Motion of the Front of the Foot.

normal imprints are shown in the accompanying illustrations. The impression of the foot is taken by having the patient step on a piece of cardboard blackened with camphor smoke.

The degree of flexibility should be examined by attempting to adduct the forefoot gently with the hands and to flex the foot dorsally with the patient's knee extended. Loss of the first of these movements is of diagnostic importance.

The presence of tender points in the sole of the foot, either under the heel or under the scaphoid, generally indicates static disturbance of the foot.

The range of variation in the contour of the foot and in the height of the arch in individual feet is so marked that from inspection it is not possible to say that a foot may or may not be the seat of symptoms. A foot apparently anatomically sound may give rise to symptoms, while, on the other hand, one excessively rolled in may be perfectly useful.[1]

Differential Diagnosis.—*Rheumatism and Arthritis Deformans.*—The diagnosis of "rheumatism" in the feet should be made with very great care and only in connection with distinctly rheumatic manifesta-

[1] Lovett: "The Occurrence of Flat-Foot among Trained Nurses." Am. Journ Orth. Surgery, vol. i., 1.

tions in the upper extremities. Pain in the knees, hips, and back may be purely secondary to a static disturbance in the foot. The frequency with which this diagnosis is made by practitioners unfamiliar with flat-foot makes it important to lay much stress on this point. The fact that no dropping of the arch of the foot can be detected by the eye by no means establishes the diagnosis of rheumatism.

An *x*-ray examination is of assistance in determining any displacement in the relation of the bones to each other occurring in the severer grades of the affection and not present in the lighter grades. It is also of value in giving information as to the presence of arthritis deformans and the existence of spurs of bones.

Prognosis.—After a time the foot may become accustomed to its altered position and painful symptoms cease. In other cases, however, the painful symptoms continue and become worse rather than better.

The condition may persist almost indefinitely, a constant source of pain and disability.

The results of treatment are as a rule satisfactory. In cases with little permanent distortion but great muscular weakness, benefit and cure can be expected from careful treatment. In cases of average severity, relief can almost always be given by very simple measures. A spontaneous cure is not to be expected.

Even after deformity of the bone takes place and the distortion is confirmed, a useful foot may be obtained if the muscular development of the leg is good. Severe deformity can be corrected by operative measures, with the restoration of normal function by after-treatment.

Treatment.—The treatment of the conditions described will depend upon the nature of the deformity, its severity, and its duration.

The principles of treatment are simple. They consist of the support of the foot in a proper position (if support is needed) and the development of the strength of the muscles and tissues until they are sufficiently strong to maintain the normal attitude. Where fixed distortion of the foot is present, it is to be corrected by mechanical or operative measures.

Supporting Treatment.—*Plates. Indication for Support.*—When the strength of the foot is inadequate to sustain the weight of the body without discomfort, mechanical support is needed. Flat-foot plates (Chapter XXI., **32**) are indicated in such cases even when the lowering of the arch is not marked to the eye, but when the symptoms of strain are sufficiently characteristic, as described above. Plates are not likely to be of use in rigid and deformed flat-foot where it is not possible to obtain an improvement in position by gentle manipulation. In such cases the restoration of a more correct position should precede the use of plates.

Casts for Plates.—For the construction of a properly fitting plate a

cast of the foot is necessary. This is made from a plaster mould of the foot placed in as near a correct position as is possible. The patient is seated and the foot is placed in a pan of plaster of Paris and water of about the consistence of melted ice cream. No weight is put upon the leg during this proceeding, and the plaster is heaped up around the inner side of the ankle and is allowed to harden. The foot is then removed from the mould, which is greased with vaseline and filled with plaster-of-Paris cream. When the latter hardens it is removed from the mould and gives a representation of the patient's foot in a somewhat corrected position. As this cast furnishes a somewhat sharp contour of the sole of the foot, a plate shaped exactly to it would be likely to present rather sharp contours and not be so comfortable as a somewhat modified shape. It is therefore necessary for the surgeon with a sharp knife to cut away something of the lower surface of the cast in order to insure in the plate an even, well-distributed bearing surface, pressing most on the points where pressure is desired. It must be remembered that the plate should furnish support to the hard tissues of the foot and not to the soft, and in fat feet more modification will be necessary than in thin ones. It is also necessary, if the plate is to be properly balanced and set evenly, that the surgeon should cut the cast where the front and back edges of the plate come, in such a way that they should be flat and approximately in the same plane; otherwise a rocking plate or one with uneven edges will result.

Another method of preparing casts for plates is to model them from moulds of the foot made in dental wax. If a sheet of quickly hardening dental wax is softened in hot water and placed upon the bottom of the foot, a mould can be taken. When it is hardened it can be removed from the foot, and can be cut and moulded to any desired shape by immersion again in hot water. In this way a wax flat-foot plate is made fitted to the boot. A plaster-of-Paris cast can be taken of this, and reproduces exactly the shape and size of the plate desired.

Manufacture and Material.—The best all-round material for the manufacture of plates is a spring tempered steel of a gauge varying from eighteen to twenty, according to the weight of the patient. For the manufacture of plates from this material, the services of an instrument-maker or of a skilful blacksmith are necessary. The cast should be furnished to him and the plate forged to fit the cast exactly. It should then be tried on the patient, before or after which it should be tempered. For final use the plate should be copper-plated and nickel-plated. In other cases it is more convenient to cover it with leather, but the moisture of the foot is more likely to rust it under these conditions than when it is nickel-plated. Galvanizing furnishes a permanent protection against rust, but the process destroys or impairs the temper of the plate. A galvanized plate should therefore be made

heavier than others. Of other material used for the manufacture of plates should be mentioned phosphor bronze, which is malleable and more easily fitted, but plates made from it are much heavier than of tempered steel. Sheet celluloid may be used for the manufacture of plates, but in order to support weight it has to be very thick, and even then is inclined to bend or break. It has the advantage that the surgeon can make and shape his own plates. The celluloid is cut of the desired shape and is bound on to the bottom of the cast by rubber tubing, which is wound round both cast and plate on the stretch; it is then immersed in boiling water, which softens it until it takes the shape of the bottom of the cast. The edges should be smoothed with a file.

Another efficient but somewhat clumsy use of celluloid may be made by the surgeon. A celluloid paste is made by dissolving celluloid chips in acetone; this is then painted on to several layers of gauze laid on the cast, between which strips pieces of steel wire are incorporated. The wires are laid on in different directions, giving strength as desired. When the celluloid has hardened, the edges of the plate should be trimmed.

Shape of Plates.—Judgment is necessary in determining the proper shape of the plate in each case, as the deformity varies both in degree and in kind. The shape should be determined by the part of the foot which needs corrective support. In the milder cases all that is needed is to furnish support to the sustentaculum tali. In other cases the scaphoid, cuneiform, and proximal end of the first metatarsal need to be raised. In some cases the tendency of the os calcis to rotate to the inner side of the foot is to be checked, and in other cases side pressure is needed on the head of the astragalus, scaphoid, and cuneiform, with counter-pressure on the outer side of the foot. The most practical way of determining what shape of plate is desirable is to have the patient stand, and by pressure with the hand to see in what place the force accomplishes the best result. In general, a plate should be higher along the inner part of its surface than on the outer, but it should not be made so sloping that the foot continually slides off. If this is the case a counter-point of pressure may be furnished by turning up the outer flange at the outer edge of the plate. Ordinarily it is advisable to have the plate support nearly the whole width of the sole, ending in front behind the sesamoid bones of the great toe and at the back end just anterior to the weight-bearing surface of the heel, or, if desired, running to the back of the weight-bearing surface of the heel.

If the anterior part of the foot is broken down, support to it should be furnished by raising the front of the plate in a dome-shaped rise, supporting the part of the foot behind the heads of the metatarsals. In flexible feet a shorter plate can be used than in rigid feet. The need of an inner flange and its height will be determined by the require-

ments of the case; the same is true of the outer flange. The plate at its outer border should not project beyond the outer edge of the shank of the boot, or it will push out the leather and destroy the shape of the boot.

Fitting and Use.—The plate should be shaped in such a way as to act as a prop to the portions of the feet which drop to an abnormal position when weight is thrown upon them. In the practical fitting of the plate, if the plate is rightly shaped, the foot when not bearing weight should lie smoothly against the bottom of the plate, not springing off at the front or back. If it springs off, it will exert more pressure than is generally comfortable. When the plate is placed in the boot and the patient stands upon it, there should be a sense of even, well-distributed pressure, and not a feeling as if the patient were standing on a ridge or lump, which will be the case if the plate is too high. If an inner flange is used it should not press too much upon the foot when weight is borne upon it. If sensitive points in the foot are present and cause pain when weight is borne upon the plate, it will be necessary to lower the plate opposite these points. When the plate is first applied it should be worn only for so long a period as is consistent with the comfort of the patient, and should then be taken out to rest the foot if necessary. If the plate is persistently a source of pain it will not give the desired relief, but will cause irritation and must be lowered until it is comfortable. No point is more commonly neglected than this, and the very common use by patients of ill-fitting supports bought at shoe-stores brings much discredit upon the use of plates. The plate should set firmly in the shoe and should not rock, and the front and back ends should be in contact with the sole of the boot.

Misuse of Plates.—The danger of injury to the feet by the too constant use of plates is to be borne in mind. The plate is to be regarded in the same light as is a crutch or cane in the case of any joint unable to bear the strain of use, and is to be discarded when the normal strength has returned and the irritability has disappeared. To continue the plate after the indications for its use have disappeared is to hamper the muscles of the feet and to prolong the unnatural condition.

Discontinuance of Plates.—When the symptoms of irritation have disappeared, a trial of the strength of the foot is to be made by discontinuing the plate for a short period and by teaching the patient to hold the foot by muscular effort in the corrected position. When the plate is first left off, prolonged standing and walking are to be avoided, and if symptoms of irritation follow its discontinuance it should be reapplied. It is a mistake to discontinue the plate suddenly or for the patient to continue to go without it if symptoms of strain are present.

Pads.—The use of felt or leather pads supporting the arch of the foot is sometimes of use temporarily or under exceptional conditions.

Such pads may be cut of the desired shape and worn outside the stocking by being fastened on temporarily by a tape passing round the foot or by being incorporated in an inner sole of leather. If they are worn for any length of time the weight of the foot stretches the leather of the boot and breaks down the shank and they cease to be of value. Felt or leather pads are frequently of use in persons with mild flat-foot who have to exercise or stand in gymnasium shoes.

The Oblique Sole.—Palliative treatment is often attempted in cases of flat-foot by making the inner side of the sole and heel of the boot one-eighth or one-fourth of an inch thicker than the outside. The weight is in this way thrown more to the outer side of the foot and the strain on the inner side is somewhat relieved. The thickness of the wedge which is necessary may be determined experimentally by building up the inner side of the boot till the desired position is obtained, as determined by the diminution in the projection of the internal malleolus. The objection to the method is that the foot slides on the incline of the sole if an effective elevation in the sole of the boot has been made and the boot is distorted by the stretching of the leather over the outer side; in addition to which, the pressure of the outer side of the foot against the boot is uncomfortable.

It is to be remembered that in the correction of flat-foot not only should the body weight fall well on the outer edge of the foot, but the great toe and head of the first metatarsal should perform their normal functions in locomotion. The method is sometimes useful in the flat-foot of children and in connection with the use of plates; in the latter case a slight elevation will sometimes diminish the strain on the inner side of the foot. Of itself, however, it must be regarded as a very imperfect method. The raising of the inner edge of the heel of the boot without changing the sole has the advantage of checking somewhat the inclination of the os calcis to roll to the inside.

Massage, Gymnastics, etc.—The supportive treatment of flat-foot should be reinforced by measures to stimulate the local circulation and to strengthen the muscles of the foot. Massage is of the first importance, but should not be pushed to the point of irritation. The use of alternating hot and cold douches or of a local hot bath followed by a cold douche is of much value. Vibratory massage, electricity, and the use of hot air may be of use in especial cases. Exercises to increase the power of the deficient muscles are sufficient, in connection with the measures already mentioned, to correct many of the milder cases. They form an important part of the treatment of all cases, mild or severe, whether or not used in connection with support to the arch, and are to be regarded as essential to treatment of any form. The toeing-out habit in standing and walking should be corrected. Individuals with strong and untrammelled feet stand and walk with but little divergence

of the angle of the feet. The greater the angle of divergence in walking and standing, the greater the tendency to strain of the tissues and to falling of the foot to the inner side.

Shoes.—Typical flat-foot, being a static deformity, is in general to be prevented if proper precautions are taken. Of these the most im-

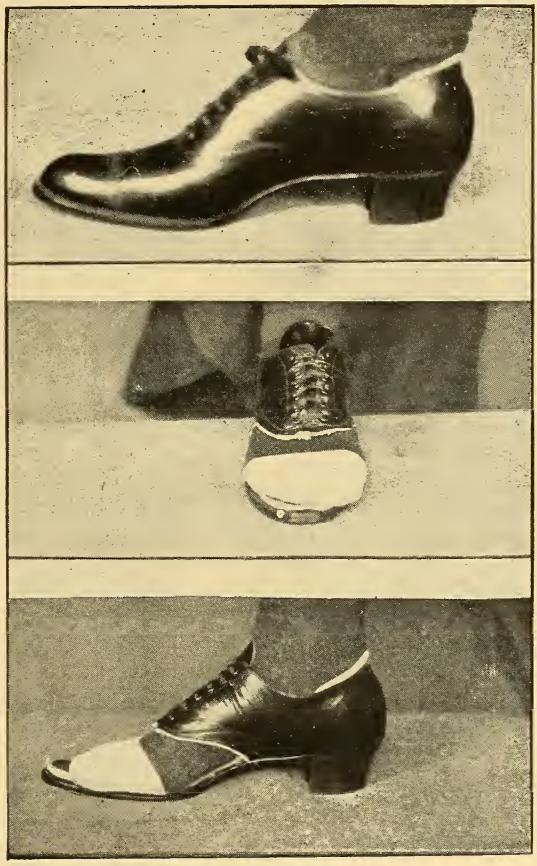


Fig. 533.—Showing Shoe Constriction of Front of Foot, with Normal Foot in Shoe Before and After Removal of Upper.

portant is footwear which does not distort or interfere with the free movements of the foot. In infants beginning to walk, in whom the body weight may be too great for the muscular strength, trouble may be averted by massage and manipulative treatment, the avoidance of great fatigue, and the use of proper footwear. In older children with the same defect, gymnastic development of the muscles of the feet should be followed out and faulty shoes avoided.

The adoption of proper footwear is essential not only to protect a foot under treatment for flat-foot from relapsing to its deformity, but

also as a preventive measure in young children. The object of a boot should be to hold the foot in an approximately correct position and not

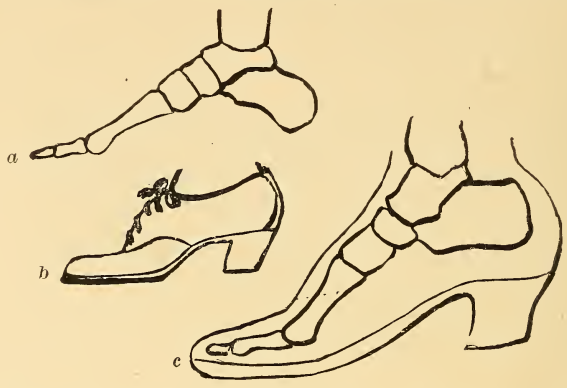


FIG. 534.—*a*, Drawing of Normal Position of Bones of Foot. *b*, Fashionable Shoe. *c*, Tracing of Skiagram of Foot in Shoe, Indicating Cramping and Downward Pressure on the First Metatarsal.

to interfere with the normal function of the foot in walking. It is obvious that the great toe should have room to help support the inner

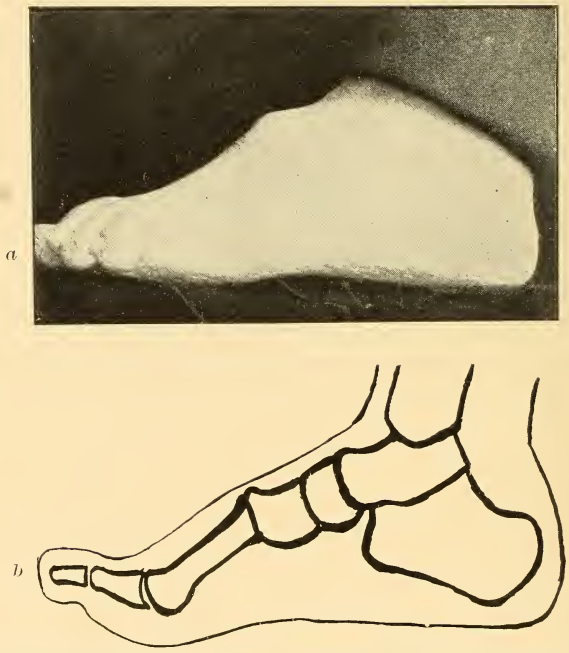


FIG. 535.—*a*, Photograph of Humped Foot. *b*, Tracing of Skiagram of Humped Foot with Irritation Exostosis of the Metatarso-cuneiform Articulation.

border of the foot; that the forefoot should not be cramped, but should have room to be placed properly on the ground, in order to perform its

weight-bearing function; and that the toes should be given room and opportunity to touch the ground in their proper relation and thus be of use in walking, and that the outer edge of the foot should have an opportunity to exert its normal function in supporting the body weight. These requirements necessitate that the boot or shoe should have a straight inner line, that the shank should be as high as the shank of the individual foot when bearing slight weight. This should not be too stiff, permitting the normal play of the first metatarsal inward and

FIG. 536.—Tracing of Skiagram of Foot in Shoe Before and After Removal of Upper.

downward, and should be slightly higher at its inner than its outer border. The forward part of the boot should be as wide as the weight-bearing foot at that point, and the toes should have room to be placed individually on the ground. The forward part of the sole should not be rolled up, but should be flat, to enable the toes to finish the step in walking; neither should the lower surface of the sole be convex from side to side, but should set squarely on the ground. The heel should not be high. The forward part of the boot should be at somewhat of an angle to the line of the long axis of the heel, that is, the forefoot should be slightly adducted on the posterior part of the tarsus. Since the position of the weakened foot is one of abduction of the forefoot, and the position of the foot under muscular support is one of adduction of the forefoot, it is obvious that the support of the foot in the former

condition is corrective in character. The upper should not be shaped too snugly upon the dorsum of the foot or be so inelastic as to prevent the flexible action of the toes.

The shape of the shoe has become conventionalized to such an extent that the general use, among the leisure class, of shoes of the shape of the normal foot is not practicable. The people of the city streets will not be shod as hunters. It is, however, practicable to limit the use of fashionable shoes for leisure hours and working boots for working hours. The boots should be adapted to the gait and use. People who use the front of the feet in locomotion, "front-foot" walkers, and those walking on uneven ground need more room in the front of their boots than heel walkers or those who walk on an even surface. Individuals

FIG. 537.—A Shoe Arranged so as not to Cause as much Pressure on the Dorsum and Preventing the Distortion.

with any tendency to flat-foot should have walking boots as well as dress boots, and the feet should be rested as much as possible in sandals and moccasins.

THE TREATMENT OF PAINFUL CASES.—In certain cases the symptoms of local irritability reach so high a grade that especial treatment is needed. Spasm of the peroneal muscles may be present, holding the foot in an abducted position and resisting movements of rectification. In this case temporary fixation of the foot in a plaster bandage is the most efficient measure. In other cases great irritability is caused by a tenosynovitis from joint inflammation incident to strain, and in these cases the treatment described for sprain of the ankle is necessary. Irritated flat-foot, however, is not so favorably affected by massage as the ordinary sprain of the ankle.

SUPPORT TO THE LEG AND FOOT.—In the severe forms, when there

is decided eversion of the foot, a support holding the leg is needed. Such may be afforded by means of a steel sole plate, with an upright passing up on the outside of the leg, with a supporting strap around the inner malleolus described in speaking of infantile paralysis, or as a simple upright attached to the outer side of the sole of the boot, with a leather support over the inner malleolus secured to the upright (Chapter XXI., **31**).

Forcible Correction.—In cases in which it is not possible to place the foot in an approximately correct position on account of stiffness and muscular contraction, it is generally unsatisfactory to attempt

FIG. 538.—Deformity Caused by the Constriction and Confinement of the Foot.

the use of a support until the position of the foot has been corrected. Such patients should be anæsthetized and the foot forcibly twisted into shape. It must be remembered that there are two elements of deformity to be corrected: first, eversion of the foot; and, second, abduction of the forefoot. This can be done manually in many cases, but in severe cases such an appliance as the Thomas club-foot wrench will be of use in giving better leverage, or the foot can be manipulated over a padded wooden wedge.

The foot should be overcorrected if possible, or in any event placed in the best obtainable position and held by a plaster bandage. It then follows the course of an ordinary sprained ankle, generally of slight degree. As soon as the patient can walk without pain, supports should be applied.

In less severe cases correction can be gradually accomplished by the repeated application of plaster-of-Paris bandages.

In extreme cases osteotomy of the neck of the os calcis and astragalus may be needed.

The removal of a wedge-shaped piece of bone from the inner side of the midtarsus has been recommended, but should not be undertaken unless it is certain that the chief obstacle to correction lies in the distorted shape of the astragalus, scaphoid, and os calcis. In a majority of cases, even the severe ones, forcible correction will be found more efficient than wedge-shaped exsection, as the distortion will be found to be distributed in various parts of the foot, and extensive removal of bone will be followed by weakening of the foot. The operative details

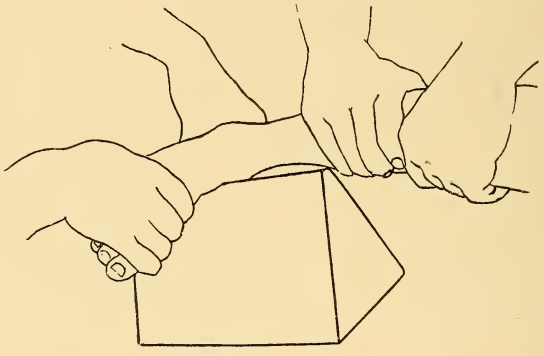


FIG. 539.—Forcible Correction of Valgus on Wooden Block. (Berger and Banzet.)

for osteotomy and wedge exsection are similar to those to be regarded in operating on club-foot, it being remembered that the deformity is the reverse of club-foot.

The most notably deficient muscles are the tibialis posticus, the tibialis anticus, the flexor longus hallucis, and the short muscles of the sole of the foot. The following simple exercises will be found useful:

The patient walks on the outer edge of the foot with the inner edge raised.

The patient attempts to separate the great toe from the second toe laterally and to hold it in that position while walking.

The patient flexes the toes while the foot is free and grasps objects in them by their plantar surface.

The patient walks with the front of the foot directed inward.

The patient sits with the leg extended and resting upon the assistant's knee. Forcible adduction of the forefoot is then made while the assistant resists lightly with one hand steadying the tibia and the other pressing against the ball of the great toe.

The patient should be taught to rise on the toes at the end of each step, finishing the step with the toes.

The patient should place the feet together in a parallel position, rise upon the toes as far as possible, and turn the heels, and, with the feet in this position, lower the body by bending the knees.

Such exercises as the surgeon directs should be performed an increasing number of times each day.

Certain other painful affections and acquired deformities of the feet are sufficiently allied to flat-foot to be considered in this connection.

METATARSALGIA.

(Anterior metatarsalgia, Morton's disease.)

This name is used to describe a cramping pain more or less spasmodic, situated between the distal end of either of the outer three metatarsal bones. It was first described by T. G. Morton,[1] of Philadelphia, in 1876.

Causation.—The pain is due to a disturbance in the normal relation of the anterior ends of the metatarsal bones, causing a pinching of the external plantar nerve between the ends of the bones, or to pressure of the metatarsals on other digital nerves, or to abnormal strain upon the ligaments connecting the metatarsal heads.[2]

The affection is thus due to the disturbed relation in the position of the metatarsals caused by faulty footwear. Normally the head of the first metatarsal bears a large part of the weight which comes upon the front of the foot. If footwear is worn which gives insufficient room for the toes and at the same time exerts a crowding pressure upon the metatarsals, the heads of the first and fifth metatarsals are unable to drop to the normal plane below the level of the other metatarsals, owing to the narrowness of the shoe. The weight therefore falls unduly on the heads of the other metatarsals, which are crowded downward as the foot slips forward in the boot.

Symptoms.—The condition is characterized by a more or less severe pain, which radiates down into the toes and often up into the leg. The pain usually appears when the patient is walking. It occurs generally between the third and fourth or fourth and fifth toes. It may be preceded by a sensation of slipping between the ends of the metatarsals, or the slipping may occur without the pain. It ordinarily comes on when the boots are on, but may sometimes be occasioned by rising on the toes in the stocking feet. The patient seeks relief instinctively by removing the boot and manipulating the foot, which relieves the acute pain. Some soreness may remain afterward and a tender spot is often found at the seat of the pain.

The attacks of pain may become gradually more frequent and more

[1] Amer. Journ. Med. Sciences, 1876.

[2] Jones: Liverpool Med.-Chir. Journ., January, 1897.

severe until a condition of disability is established, the patient dreading walking. Spontaneous recovery may occur, but is uncommon.

The foot may be normal, so far as can be ascertained on inspection. Oftener, however, one or more of the following variations from the normal may be detected.

1. The foot may be weakened and the standing position show slight dropping of the arch.

2. The anterior arch of the foot, or the arch normally formed by the heads of the metatarsal bones, if looked at in a cross section of the foot, is relaxed and flattened. The heads of the second, third, and fourth metatarsals are on a lower level than normal.

3. Dorsal flexion of the foot may be limited on manipulation.

Callosities may be found under the heads of the metatarsals, and one or more of the metatarsal heads may be felt unduly prominent in the sole of the foot.

Motion of the toes, especially in severe cases, is apt to be limited in the direction of plantar flexion.

Diagnosis.—This affection is frequently diagnosticated as neuralgia, for which only general treatment is prescribed, yet the diagnostic symptoms are perfectly well marked and definite and not like those of any other affection.

The **prognosis** without treatment is not good; the attacks as a rule become more frequent and painful, though spontaneous recovery does rarely occur. With proper mechanical treatment most patients recover, but occasionally very obstinate cases are seen which resist all the ordinary methods of treatment.

Treatment.—It is obvious that if any static deformity of the foot exists it should be corrected. If the weakened foot is present a proper plate should be applied, brought well forward with an elevation behind the distal ends of the metatarsals. If the anterior arch is relaxed and flattened, a felt or metal pad should be placed under it behind the heads of the metatarsals. In short, measures should be adopted to relieve the front ends of the metatarsals from pressing down on to the sole of the foot in finishing the step in walking.

Proper boots with a broad sole should be worn, and compression of the front of the foot by boots should be avoided. The normal flexibility of the toes should be cultivated by proper exercises. In some cases, however, compression of the shafts of the metatarsals for a time affords relief. In these cases it can be afforded by adhesive plaster, by bandaging, or by a boot made tight over the shafts of the metatarsals. Removal of the distal end of the fourth metatarsal has been advocated as a measure of treatment, but it is not often necessary to resort to this.

HALLUX VALGUS.

This name is applied to the outward displacement of the great toe. In the normal foot, as seen in children and people who do not wear boots, the long axis of the great toe when prolonged backward passes through the centre of the heel (Meyer's line).

Causation.—This deformity of the great toe, however, is not necessarily the result of tight shoes, for the deformity may come in people who have worn only comparatively loose ones. The upper leather of shoes, being more yielding than the sole, stretches under the pressure of use, or is stretched to avoid pressure upon the metatarso-phalangeal articulation. The boot is not stretched at its extreme end

FIG. 540.—Hallux Valgus. Great toe under.

FIG. 541.—Hallux Valgus. Great toe over.

and it inevitably becomes, in a degree, conical in shape on this account, being broader across the ball of the foot than at the tip end. In the act of walking the foot necessarily slips inside of the boot to a certain extent, and if the shoe slips backward and the foot forward, a certain amount of pressure will come upon the inner side of the end of the great toe, tending to displace it outward.

This deformity may also be occasioned by short boots, and the ordinary pointed-toe boots, or any boot which does not give more room for lateral spreading at the toes than at the metatarso-phalangeal articulation, would necessarily give rise to the trouble. Stockings are also a factor in its production.

Symptoms.—When the deformity continues for any length of time, alteration in the relation of the bones of the metatarso-phalangeal joint takes place. The head of the metatarsal is partly uncovered as the phalanx is pushed to the outer side, and the head of the metatarsal may become enlarged from growth of the bone due to periosteal irritation. The skin over this prominent joint may grow thick and a bursa form over it. This may become inflamed, giving rise to an extensive cellulitis,

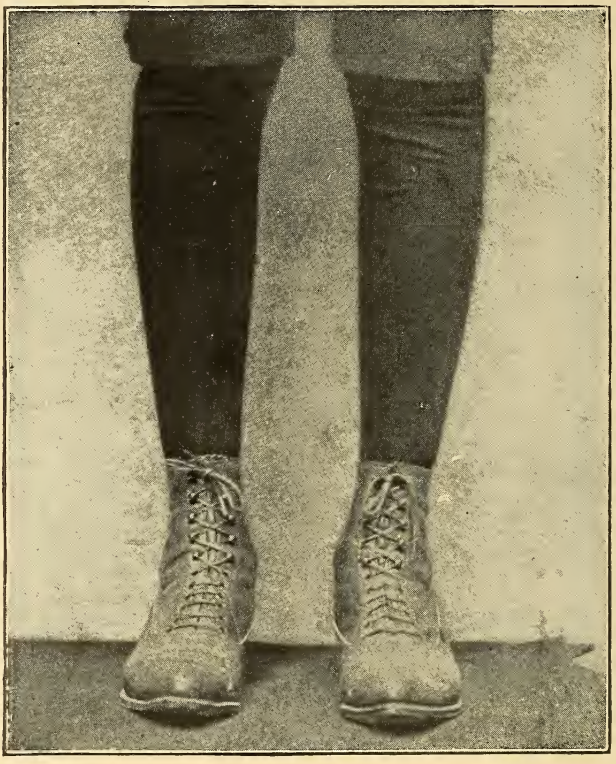


FIG. 542.—Shoes Causing Hallux Valgus, Crowded Little Toes, and Weakened Toes.

which may include the whole dorsum of the foot, which may suppurate and cause necrosis of the bone. This latter termination is, however, rare and occurs only in neglected cases. The inflammation of this bursa is known as a *bunion*.

The symptoms due to hallux valgus in the non-inflammatory stages are chiefly those resulting from the alteration of the shape of the foot. In aggravated cases a peculiar gait is noticeable, the foot is thrown out, and there is loss of elasticity in the gait. There may be pain and irritability in the great toe-joint, and in severe cases extreme pain and difficulty in walking, which is usually attributed by the patient to gout.

On examination, sensitiveness of the metatarso-phalangeal joint is detected on pressure. In its more marked degree it is almost exclusively an affection of adult life, but is occasionally seen in adolescence. In a slight degree it is almost universally present after middle childhood.

FIG. 543.—*X*-ray of Hallux Valgus, Showing how the Shoe Causes a Deformity.

Treatment.—The treatment of hallux valgus in early cases may be carried out by wearing a splint of steel or hard rubber along the inner border of the foot fastened behind to the metatarsus. To the front end of this splint the toe is bandaged or strapped and thus pulled outward.

The use of a toe post is sometimes beneficial. That is, a metal partition is attached to or passed up through the sole of the boot, which shall come between the first and second toes and hold the great toe in an improved position.[1] For the use of this toe post a stocking is re-

[1] Sampson: Johns Hopkins Bulletin, January, 1902.

quired which shall have a division between the great toe and the other toes (Chapter XXI., **33**). The use of a foot-plate curved to support the arch of the foot will be of use when the foot is weakened or flat.

Shoes should be so constructed that no pressure is possible which will force the great toe to the outer side. The sole of the shoe should be not only as broad as the sole of the foot, but in cases in which there is a tendency to this deformity, room should be made in the front of the shoe for the first metatarso-phalangeal joint.

Operation.—In old cases attempts to correct the deformity by such means as those mentioned are generally unsuccessful and operative

FIG. 544.—Hallux Valgus or Out-toe.

measures may be adopted. The joint may be resected through an incision along the inner and upper surface of the joint.

The ends of the bones composing the joint are then exposed and dissected freely enough to be pushed out of the wound one at a time. The articular surfaces are sawed through or cut off with heavy bone forceps in such planes that when the cut ends are in apposition the toe will lie in the desired straight line. The wound is then closed and a plaster-of-Paris bandage applied over the antiseptic dressing, which must be applied with much care of the position of the toe. Wiring of the bones is not necessary.

The use of properly made shoes is essential for after-treatment, and also for the prevention of the increase or recurrence of the deformity.

HALLUX VARUS.

This deformity is not a common one, and is known also as in-toe or pigeon-toe. It is rarely of any importance, and although often congenital in origin, it may occasionally be seen in young children with flat-foot, and the writers have observed it in a few cases of overcorrected club-foot in which a valgus has resulted. It is also seen in connection with severe knock-knee at times.

This distortion does not generally require treatment, and the use of ordinary shoes is sufficient to correct the deformity.

HALLUX RIGIDUS.

This deformity is sometimes seen in adolescents, and is a stiffness of the metatarso-phalangeal joint of the great toe. The deformity may may be a flexion of the proximal phalanx of the great toe through 30° to 60°, with extension of the second phalanx, or the joint may be rigid in the straight position.

The **symptoms** vary with the stage of the disease. Early there may be slight pain over the joint and painful motion, but the cases rarely come to the surgeon's notice at this time. Later there is swelling over the joint, with tenderness, and perhaps an enlargement of the bone itself. The usual atrophy after ankylosis often occurs here.

The condition is often associated with flat-foot. Ill-fitting shoes also have an influence in causing the distortion. At times it arises from an injury.

The **treatment** in the early stages will consist in removing the exciting cause and properly supporting the foot. If there is pain, with signs of inflammation, rest with local applications is indicated, and later protection by splints with support of the arch of the foot. In inveterate cases excision of the joint may be necessary.

HAMMER TOE.

This deformity consists of a claw-like contraction of one of the toes, usually the second or third. The condition is one of flexion of the second phalanx, with extension of the third, so that the pressure on the ground is sustained by the *distal* phalanx. Over the upward projecting joint there is usually a callosity, which may cause considerable annoyance.

The origin of the deformity is not well understood, but in some cases it is apparently caused by short boots.

In the slight degrees and early stages of the deformity the patient experiences but little discomfort, and such cases are not, therefore,

commonly seen by the surgeon in this stage. Later, however, locomotion becomes difficult and painful.

In children and adolescents the deformity can generally in all but the severest cases be corrected by simple mechanical treatment. The toe should be bandaged or strapped to a rigid plantar splint, which can easily be made of tin. The strapping should be renewed often enough to keep the toe extended. In children it can be corrected if necessary by subcutaneous section of the contracted fasciæ, forcible straightening,

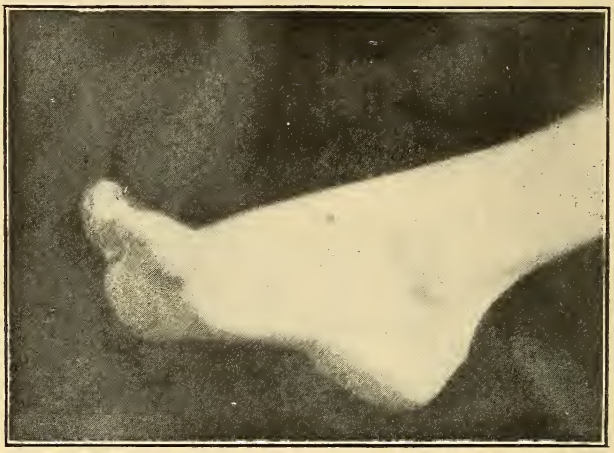


FIG. 545.—Drawing up of the Toes, Caused by Pressure of the Shoe on the Dorsum of the Foot.

and fixation in a straight position by means of splints and adhesive plaster.

After correction by mechanical means the toe shows a tendency to recontract and must be carefully watched.

Amputation at the interphalangeal joint is of no use, as the proximal phalanx remains still elevated.

In severe cases it is possible to excise the prominent phalangeal joint of the toe which projects upward, and, by taking out sufficient bone from the phalanges, to bring two bony surfaces together, which will unite and keep the toe straight and flat.

To amputate the second toe when it is affected will cure the deformity, but is objectionable because it leaves a space between the great and third toes, into which the great toe is likely to be crowded over, resulting in a severe type of hallux valgus.

FLEXED OR "CLAWED" TOES.

A contracted position of several toes is sometimes seen, either as a result of improper shoeing or as a sequel to a previous paralysis of some of the muscles of the foot. It also occurs at times in connection

with what is spoken of as contracted foot. The tendons and fasciæ will be found shortened.

This deformity is to be treated in the same way as the contraction of one toe. In this, as in all similar affections of the toes, properly made shoes are necessary to prevent relapse or to secure permanent recovery.

In obstinate cases, all contracted fasciæ or tendons should be freely divided and the toes retained in a corrected position.

PAINFUL HEEL.

A tender and painful area under the middle of the heel exists at times, and is spoken of sometimes as "policeman's heel." It seems to be associated with any one of three conditions:

1. The radiograph may show a bony spur projecting forward from the front lower edge of the tuberosity of the os calcis. This may or may not be associated with exostoses elsewhere in the tarsal bones.

2. It may be associated with inflammation of the bursa under the os calcis.

3. It may be the expression of a static disturbance (some degree of flat-foot), in which the chief strain falls on the posterior insertion of the plantar fascia.

The treatment consists in the application of a foot-plate depressed under the painful area.

POST-CALCANEAL BURSITIS.

(Achillodynia, Achillobursitis, Anterior Achillobursitis.)[1]

A tender swelling at the junction of the tendo Achillis and os calcis is not infrequently met. Plantar flexion of the foot is painful, and the patient walks with the foot everted and avoids rising on the toes. The affection may be unilateral or bilateral, and is rather resistant to treatment[2] and liable to recur when nearly well.

It generally follows a long walk, prolonged skating, or a sudden misstep throwing the weight on the toe. At other times it seems to be caused by the pressure of the leather at the back of the boot binding the tendo Achillis.

For the milder cases restricted and everted use of the foot, douches, and the use of a cane will be sufficient to effect a cure, but the improvement is slow. It is often necessary to remove pressure over the painful area by splitting the heel of the boot in the middle line behind and setting in a loose piece of leather between the spread edges.

[1] Albert: Wiener med. Presse, January 8th, 1893.

[2] Rossler: Deut. Zeit. f. Chir., lxii., 1 and 3.

In resistant and very acute cases the application of a plaster-of-Paris bandage to the leg and foot will be necessary.

An inflammation of a superficial bursa between the tendon and the skin occasionally occurs from pressure of the boot heel. Its treatment obviously consists in the removal of the pressure.

SYNOVITIS OF THE TENDO ACHILLIS.

Symptoms somewhat like those described occur at times in connection with a tenosynovitis of the tendo Achillis, which is shown by the usual signs of swelling of the sheath of the tendon above the os calcis, tenderness along its course, and silky crepitus. The affection is readily controlled by the milder class of measures mentioned above.

EXOSTOSES OF THE TARSAL BONES,

especially of the os calcis, are found from time to time accompanying a painful and even a disabling condition of the foot. Inflammation of the post-calcaneal bursa has been described in connection with this condition.[1] The exostoses are found by skiagraphs.

The etiology is obscure. The affection is obstinate and recovery slow. It is not, as a rule, much benefited by treatment, and the removal of the exostoses has not regularly been followed by relief and should not be undertaken in the very acute stage.

Rest, dry heat, fomentations, douching, massage, etc., all have their place in improving certain cases. Partial relief is often to be obtained by the use of a support to the arch of the foot, relieving the heel from some of its pressure.

[1] Painter: Orth. Trans., vol. xi. (with bibliography).

CHAPTER XXI.

PRACTICAL DETAILS OF APPARATUS.

1. Plaster-of-Paris bandages.—2. Celluloid bandages.—3. Leather splints and jackets.—4. Antero-posterior support for Pott's disease.—5. Oval ring head support.—6. Anterior head support.—7. Thomas collar.—8. Quadrilateral back brace.—9. The gas-pipe bed frame.—10. Traction hip splint.—11. Convalescent hip splint.—12. The double upright hip splint.—13. Thomas hip splint.—14. Thomas knee splint.—15. Thomas caliper splint.—16. Jointed knee splint.—17. Fixation ankle splint.—18. Knock-knee brace.—19. Bow-leg brace.—20. Anterior bow-leg brace.—21. Antero-posterior bow-leg brace.—22. Tempered steel uprights.—23. Brace with movable shoulder-pieces.—24. Torticollis brace.—25. Caliper apparatus for anterior poliomyelitis.—26. Supporting leg brace for anterior poliomyelitis.—27. Equino-varus splint.—28. Apparatus for talipes equinus.—29. Apparatus for talipes calcaneus.—30. Apparatus for talipes varus.—31. Apparatus for talipes valgus.—32. Flat-foot plates.—33. Toe post.

It is obviously desirable that surgeons undertaking the treatment of orthopedic cases should not be wholly dependent upon instrument-makers. Not only is it important that the surgeon should be able to fit and adjust his own apparatus, for except in the larger cities instrument-makers are not available. The following details are given in the hope of enabling surgeons to undertake the measurement and construction of the simple forms of the common apparatus. In most cases the construction of the apparatus below is within the reach of a blacksmith of ordinary skill, and, with the assistance of a harness-maker to do the leather work, the construction of the apparatus described should not present any intrinsic difficulty. The forms of apparatus described are those which for many years have been in satisfactory use at the Children's Hospital, Boston. It need hardly be said that nicety of finish and elegance of construction do not add to the efficiency of the apparatus, however desirable these qualities may be in making apparatus for persons who are able to bear the extra expense. In order to secure uniformity the apparatus described is adapted for the use of a child ten years old, and for patients much older or much younger allowances must be made in the strength and weight of the apparatus.

1. PLASTER-OF-PARIS BANDAGES

Plaster bandages are of two types, the quick setting and the slow setting. The quick setting are to be used when rapidity of application

is desirable, as in the case of young children, in the application of plaster jackets in suspension, and in all conditions where for any reason it is desirable to save time. Splints made with quick-setting bandages are more liable to break, and are not so durable as bandages which take more time in setting. The setting of plaster bandages is hastened by the addition of salt or alum to the water in which they are soaked, about a tablespoonful to a pail of water. It is also influenced somewhat by the kind of plaster and gauze used. The setting of plaster is delayed by the presence of glue either in the sizing of the material used or added to the water if desired.

Material.—The best material to be used for plaster bandages is white crinoline, 40 by 40, not sized or starched.

If crinoline sized with glue is the only kind obtainable, it should be washed and dried, to remove the glue, and then cut and rolled into bandages. As it wrinkles in drying it is more difficult to cut and to handle under these conditions. Crinoline sized with glue sets very slowly and is objectionable on that account. Crinoline sized with starch costs from six to nine cents a yard. Bandages may be also made of coarse cheesecloth, but it is more difficult to cut than the stiffer crinoline and on the whole is less satisfactory, but it is cheaper, costing from about three cents a yard upward. As the best bandage is one that will hold plaster in its meshes and not simply smeared on its surface, the material used should have a coarse mesh. The best plaster splint is not one of alternate layers of cloth and plaster, but one in which the layers of cloth are cemented together by plaster of Paris.

Size of Bandages.—For use in the application of bandages for the legs and for plaster jackets, the width of the bandages should be from three to four inches and the length four yards. The weight of a bandage four inches wide and four yards long should be approximately from five to six ounces, including the plaster rubbed in. For the correction of club-foot in young children, the width of the bandages should be two inches and the length not over two or three yards.

Plaster.—High-grade, finely pulverized plaster, sometimes called "dental," is the quickest and best for general use. Ordinary plaster of the highest grade sets somewhat more slowly. The plaster should be kept in a dry place and preferably should be fresh, and if at all old or damp the bandages should be dried in an oven before using. Powdered dextrin may be added to the plaster before winding the bandages, in the proportion of about one to ten, but it delays the setting, although it makes the bandage more durable. Five per cent of Portland cement added to the plaster before rolling quickens the setting and hardens the bandage, but discolors it somewhat. For general use plaster of Paris is the best material.

Rolling of Bandages.—Although many forms of machines for rolling plaster bandages have been described, most surgeons find it more convenient to have them rolled by hand. The gauze or crinoline bandage is laid flat on the table and a heap of plaster is placed on the table near it. A handful of the plaster is then laid on the bandage, and, with a flat piece of splint wood or a case knife, this handful of plaster is pushed along over the bandage and any excess of plaster thus removed. The end of the bandage impregnated with plaster is then rolled, the bandage pulled along, and another handful of plaster placed upon it and the bandage impregnated in the way described above.

Bandages should be rolled loosely; if they are rolled tightly the water will not saturate the centre of the bandage.

Soaking the Bandage.—The bandages should be soaked in a pail containing at least six inches of water, sufficiently warm not to chill the patient. The bandages are put in the pail resting on their ends, and are allowed to remain until bubbles have ceased to come to the surface of the water. They are then squeezed by holding them with the hand over each end to prevent the escape of the plaster until they are sufficiently dry not to drip. If they are taken out too soon the plaster is not sufficiently softened, and if they are left too long they will set in the water.

Protection of Patient's Skin.—When it is desirable to put on a bandage which will not be too bulky and when there is no reason to suppose that swelling will occur after the application, the skin may be protected by a stocking, by one or two layers of a gauze bandage smoothly laid on, or by a layer of stockinet, over which the plaster is smoothly applied. When there is reason to suppose that there may be swelling, when the patient lives at a distance, or when the bony prominences are very marked, it will be desirable to protect the skin and to guard against harmful pressure by the application of layers of sheet wadding smoothly applied in sufficient thickness to guard against pressure. This is especially the case in the application of bandages after osteoclasis and in the correction of club-foot. In the application of jackets the skin should be protected by putting on, first, a thin sleeveless undervest without buttons, known as "women's ribbed undervests," costing about three cents a piece when bought by the dozen; or a layer of stockinet is placed on the trunk and cut off at the desired length. Stockinet is sold in tubes of various sizes and the required piece can be cut off of the desired length. Bony prominences should be padded by felt pads. The felt may be obtained in varying thicknesses from one-quarter to three-quarters of an inch, and varies in quality from what is known as saddle felting to piano felting, which is the best grade. The felt should not be put next to the skin, but put outside of whatever is used to protect the skin from the plaster. In the application of plas-

ter jackets it is not necessary or desirable to wind the body in sheet wadding.

Application of Bandages.—Bandages should be applied with a smooth, even pressure and uniform tension throughout each turn. They should not be put on with too much tension, reverse turns should never be made, and there should be no correction in the position of the joint or limb after the plaster has begun to set; otherwise folds will be made in the inside of the bandage, which may cause sloughs or impair circulation. Every portion of each turn should be thoroughly rubbed with the hand to unite the layers, and nothing in the application of a proper kind of bandage contributes so much to the stability and strength of a splint or jacket as vigorous rubbing at every step of the application. When bandages are weak or when extra strength is desired, the bandage may be folded to and fro, each duplication being smoothed down with the hand until the desired number of layers is obtained. This area made even is smoothly covered in by circular turns. In general, however, six to ten layers of a properly prepared and applied bandage are sufficient to give strength.

The edges of the bandage may be finished by cutting with a knife or by turning down over the outside of the bandage one-half of an inch of the material protecting the skin, and winding over the turned-down part one or two turns of plaster bandage. This leaves the edge of the bandage protected by soft material.

The surface of the bandage may be polished when it is nearly dry by rubbing with the wet hand or by rubbing with the plaster paste which is found in the bottom of the bandage pail.

The hands of the surgeon may be protected by the use of thin rubber gloves, which will prevent roughness of the skin caused by the use of plaster of Paris. A properly applied plaster bandage should be sufficiently dry in five or ten minutes from the time that the application has ceased.

In the case of plaster bandages to the leg which are inclined to slip down over the ankles and give trouble, they may be anchored in place by the use of a strip of sticking plaster, three or four feet long and one inch wide. This sticking plaster is applied to the outside of the leg from the knee down under the sheet wadding. A few layers of plaster bandage are then put on, and the strip of sticking plaster which projects below the lower edge of the bandage is then turned up and incorporated in the bandage.

Removal of Bandages.—If it is desired to remove the bandage, the plaster should be moistened by means of a medicine-dropper with either water or a weak solution of acetic acid. When the plaster is wet it can be cut with ease by a sharp knife. The most convenient apparatus is either a knife known as a shoe knife or a knife with a concealed

blade known as the electrician's knife. It is not desirable to make the cuts toward the patient's skin, but parallel to or away from it. After the application of a plaster jacket, if for any reason it is feared that there may be constriction of the circulation, it should be cut down in the front immediately after application, so that it may be sprung open in case of emergency. If sinuses are to be dressed, or if for any reason it is desirable to remove the pressure from a given point, windows may be cut in the bandage. It is also possible by means of two cuts on the opposite sides of a bandage to remove a lid, through which the joint or limb may be inspected, and which can be replaced. This lid can be held in place by bandaging with a wet gauze bandage. When bandages are likely to be worn for a long time, and especially in the application of spica bandages to the hip, it is desirable to leave a strip of soft gauze inside of the bandage for cleansing purposes. The two ends of this above and below the bandage should be left sufficiently long to be fastened together. By pulling this strip of gauze to and fro, crumbs, etc., are removed. The indications for the early removal of a plaster bandage are the presence of constant pain, an offensive smell, or the detection of a serous discharge staining the outside of the jacket. These signs point to harmful pressure or the formation of slough. The time which a plaster jacket or bandage should be worn varies, of course, with each case.

2. CELLULOID BANDAGES.

Celluloid jackets or bandages are light, clean, and fairly durable. They are not dangerous when exposed to heat, and if touched with a lighted match burn with about the same rapidity as sheet wadding. They cannot be applied directly to the patient, but must be made on a dry plaster cast of the limb or trunk. To manufacture this the plaster bandage is applied and immediately removed, fastened together, one end closed, and the side not stopped is filled with a plaster-of-Paris cream. The mould is then removed and the cast smoothed, dried, and shellacked. For the application of celluloid splints a celluloid paste is made by dissolving celluloid chips in acetone or wood alcohol. This paste, which should be about as thick as ordinary mucilage, is used as a paint to cement together and harden the layers of some cloth placed over the cast. This cloth may consist of cheesecloth bandages, stockinet, or undervests similar to those described for plaster jackets. Each layer of cloth receives several coats, each one of which is allowed to dry. When the cloth material takes up no more celluloid, another layer is added and painted in the same way. From six to ten layers of the kind of undervests described for plaster jackets are required to make a durable celluloid jacket. The thickness of the bandage in each case must be a matter of individual judgment. After a sufficient thickness has

been reached it is most important to leave the bandage or jacket on the cast until it is thoroughly dry inside and out; otherwise it will warp when taken off. When it is thoroughly dry it is cut and removed, the inside finished with a fresh painting of celluloid, the edges are trimmed and bound with leather, the jacket is perforated by holes throughout, and leather straps one inch wide, containing studs or lacings from one to two inches apart, are sewed to the jacket, one inch or more from each side of the cut extending its entire length. For the use of plates and splints, for the forearm, for instance, sheet celluloid or pyroline may be used, of a size from one-thirty-second to one-quarter of an inch thick, which is softened in hot water and shaped to the cast by binding it on with rubber tubing wound on the stretch, the cast and celluloid being immersed in boiling water until the celluloid is shaped to the cast. The edges should be smoothed off with a file, and the surface of the celluloid may be polished if desired. The white variety of celluloid is more brittle than the transparent.

3. LEATHER SPLINTS AND JACKETS.

Moulded leather splints and jackets are made from oak-tanned English leather, which should not be "filled" or "stuffed." The finished leather is not useful for this purpose. The leather is cut of the desired pattern and softened by soaking in water. When it is thoroughly flexible it is stretched over a plaster cast of the limb or trunk and made to conform to all the curves of it. This may be accomplished by fastening one edge and hammering or pressing it to fit the hollows and fastening it by tacks on the other edge when it is properly moulded, or it may be wound on to the cast by means of a rope encircling it in closely fitting turns. After being shaped it is allowed to dry on the cast and removed. It will retain the shape which it assumed when wet, if it is thoroughly dry. If it is wished to stiffen the leather in order to secure a firmer support, especially in the case of jackets, the moulded leather splint is painted with hot bayberry wax until it ceases to absorb it, and it is then allowed to dry. The bayberry wax discolors the leather somewhat and gives a dull finish. If it is desired to have a highly polished

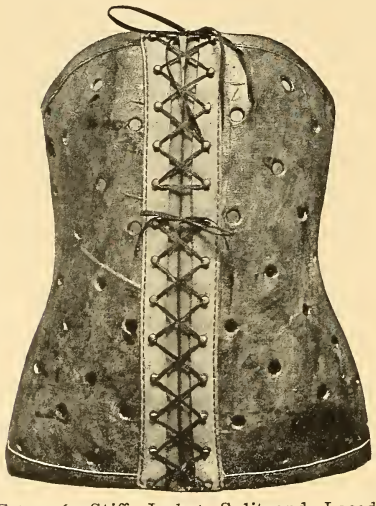


FIG. 546.—Stiff Jacket Split and Laced. (Children's Hospital Report.)

and non-absorbent surface, the jacket is now painted with a solution of shellac inside and outside and allowed to dry thoroughly. Several coats are necessary. This forms a fairly durable finish, which in time softens somewhat under the influence of heat and perspiration and pressure. Jackets and splints finished in this way do not need to be reinforced with steel unless a great deal of pull or pressure is coming upon them. If desired they can be reinforced with strips of steel fastened on the outside and riveted to the jacket. Such steels may be protected from rust by nickel-plating or may be covered with kid sewed over them. Jackets and splints should be provided with the leather lacings mentioned in speaking of celluloid jackets.

4. ANTERO-POSTERIOR SUPPORT FOR POTT'S DISEASE.

The apparatus consists of four parts: (*a*) *Two uprights.* (*b*) *A bottom piece.* (*c*) *Two shoulder pieces.* (*d*) *One or two cross bars.*

(*a*) The *uprights* reach from the seventh cervical vertebra to one inch below the posterior superior spine of the ilium. They should run on each side of the spine over the transverse processes. They are curved to fit the tracing of the spine made with the child lying on the face and taken over the transverse processes of the spine. Some alteration in this curve may be necessary to suit the standing position. For a child ten years old the uprights should be made one-half of an inch wide and about one-sixteenth of an inch thick, being made of No. 8 gauge cast steel. There should be a pad plate on each upright, reaching from the level of the highest point of the deformity to two vertebræ below the lower part of the deformity. They should be of spring steel gauge No. 16, three-quarters of an inch wide, shaped to fit the curve of the upright and also curved from side to side if necessary to fit the lateral contour of the deformity; otherwise they may bear only on the inner edge. They are fastened to the upright by a rivet at their top end, and if increased pressure is desired they may be wedged forward from the upright. They are covered with thick, firm felt or with leather. They may also be made of celluloid or hard rubber accurately fitted to the contour of the deformity, but the latter are difficult to make comfortable and adjust.

(*b*) *Bottom Pieces.*—The bottom pieces consist of two vertical pieces behind and to the inner side of the trochanter. These are joined above the posterior superior spines of the ilium by a transverse piece rounded posteriorly to fit the contour of the sacrum and not strike bony prominences. The whole bottom piece should thus consist of one piece, shaped like an inverted U, finished below with circular plates, the size of a fifty-cent piece, padded with felt, covered or not with leather. The vertical measure for the bottom piece should be taken from above the

posterior superior spine to one inch above the level of the tuberosity of the ischium. The lateral measurement consists of the distance between the post-trochanteric fossæ. The material is the same as the upright.

(*c*) *Two Shoulder Pieces.*—The shoulder pieces are two in number and separate. They are of the same width as the upright, are made of

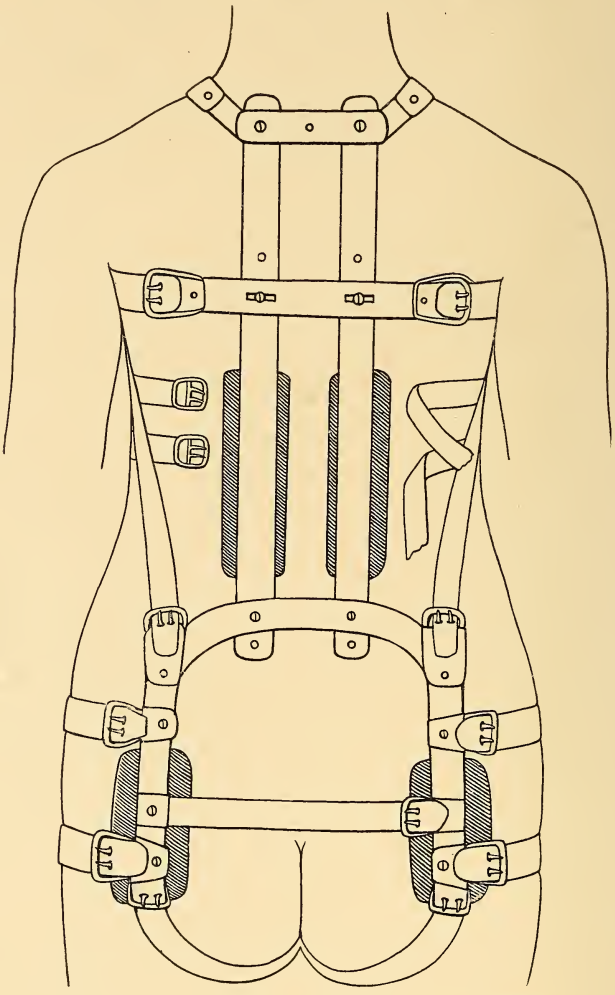


FIG. 547.—Antero-posterior Support for Pott's Disease.

a flexible steel, No. 14 gauge, one-sixteenth of an inch thick, and are riveted to the top of each upright. They are bent outward on the flat at an angle of about forty-five degrees, and are also curved downward to conform to the curve of the shoulder. They should reach from the top of the upright to the forward edge of the trapezius. The measurement is the distance from an inch or more below the top of the upright to the

forward edge of the trapezius. The curve outward begins at the top of the upright.

(*d*) *Cross Bars.*—These are flat transverse bars. The first, in length is slightly less than the breadth of the trunk at the axillary line. It is fastened to the uprights at a level slightly below that of the axilla, and if necessary should be bent backward in its outer part so as not to bear on the scapulæ. The measurement is as given; the material should be the same width as the upright, made of sheet steel, gauge No. 14. A second cross bar may be added two or three inches below the one described and slightly shorter than the other, and in length is less than the breadth of the trunk. It can be omitted in thin patients. These pieces are fastened to the upright by stout rivets, the edges are

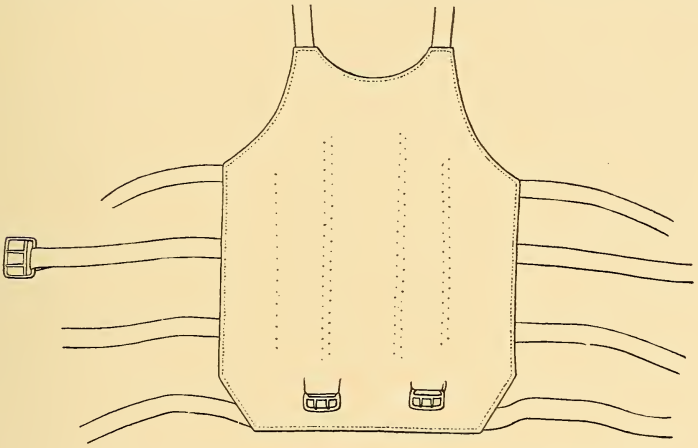


FIG. 548.—Apron for Use with Antero-posterior Spinal Support.

smoothed and rounded, and all the parts should be fastened to the posterior surface of the uprights.

Buckles.—Brass buckles, seven-eighths of an inch in width, should be fastened on leather tabs and riveted to the brace by means of holes drilled in it. There should be one pair at the bottom of the U piece, and, if perineal straps are to be used, two pairs. A pair should be fastened to the top of the U piece, and in larger children another pair to the middle. There should be a buckle at each end of each cross bar. In place of a buckle at the end of the shoulder piece, which is unsightly and causes the clothes to stand away from the shoulders, a short leather strap should be fastened on the top end of each upright, and to these straps should be attached the axillary straps and another one to be described, which is used in certain cases.

Apron.—The brace is held to the body and made efficient as a lever by means of an apron covering the anterior surface of the body and fastened to the brace at several levels. This apron is made of stout

cloth known as Hadley sheeting. The width of this is from the middle line of one side of the body to the middle line on the other; roughly it might be described as ending at the anterior axillary line. Above it should not reach as far up as the top of the sternum; below it should extend to the symphysis pubis. The upper corners are cut out in front of the shoulders in a sweep, concave downward and inward. The apron is smoothly fitted to the curves of the body, especially of the abdomen, by means of gores or gussets at the edges if necessary. Wrinkling may be prevented by stiffening the apron at the waist with corset steels or bones. The edges of the apron are finished by one-half of an inch hemming.

Finish of Brace.—When the splint is finished it should be nickel-plated, blued, or japanned to prevent rusting. The skin of the back should be protected from the brace above and below by a square of felt or leather loosely attached at the top and at the U-piece below. This should cover only the points of contact with the skin. The shoulder piece, if projecting beyond the uprights, should be covered with moose

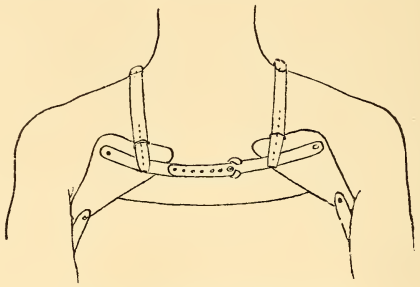


FIG. 549.—Taylor's Chest Piece.

hide, thick chamois, or felt. If the anterior surface of the brace rusts, which it should not do if nickel-plated, the clothes of the patient may be protected from rust by laying a pad of felt under the brace.

Straps from the Apron to the Brace.—These are made of webbing tape, one inch wide, costing four cents a yard. A strap on each side at the level of the axilla is sewed to the edge of the apron and passes around to fasten into the buckle at the end of the upper cross-bar. There should be a strap on each side on a level with the top of the U-piece to fasten to the buckle there. There should be a strap on each side at the bottom of the apron to fasten to the buckle at the bottom of the U-piece. In larger children, where there is a buckle in the middle of the U-piece, there should be an extra pair of straps on a level with these buckles. Two longer straps, one carrying a buckle, should be sewed to the middle of the apron, and these pass around the back outside of the brace and are buckled together, forming an additional strap. At the top of the brace an axillary strap should be sewed on

each side to the leather strap fastened to the top of the cross-bar. These axillary straps pass around the shoulders and through the axilla to the buckle in the end of one of the cross-bars from the tip of the shoulder-piece. To the leather on the top of the shoulder-piece is also sewed a strap on each side, which passes to buckles sewed at the top edge of the apron. These straps should be padded by being wound with sheet wadding and covered with canton flannel or a soft leather. Perineal straps padded in the same way, one on each side, should pass

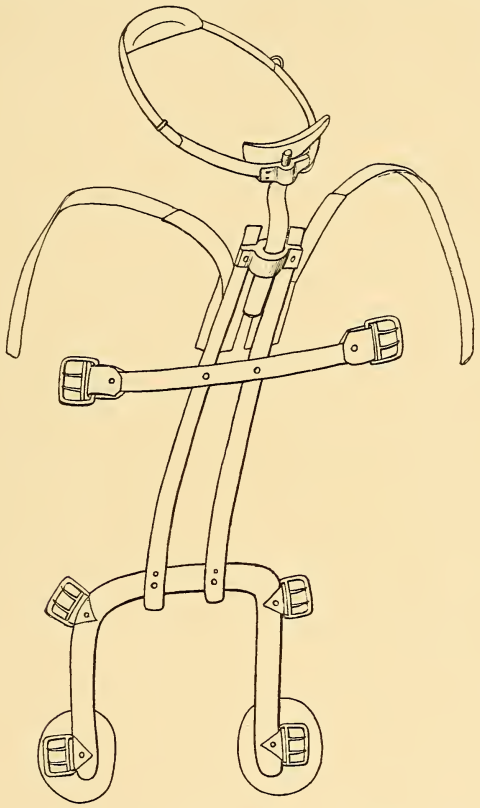


FIG. 550.—Oval Ring Head Support Added to tee Antero-posterior Support. (See Fig. 76.)

from the lower end of the apron at a point opposite the top of the fold in the groin, to a buckle to the bottom of the U-piece. They are an important addition to the security of the brace and are essential in disease of the lower part of the spine or when the brace tends to ride up. They are not to be used in connection with head supports.

A leather gorget may be used for the upper part of the chest when it is desirable to prevent the pressure on the chest from the top of the apron. It is used independently of the apron and the top of the apron is cut away. When this is done the axillary end of the leather gorget

should be finished with webbing straps, one on each side, which are fastened to extra buckles placed at the top of the U-piece of the brace.

Head supports are needed in connection with the antero-posterior support or the plaster jacket in Pott's disease of the upper part of the spinal column.

5. OVAL RING HEAD SUPPORT.

This is to be worn in connection with the antero-posterior spinal support, and consists of (*a*) an *oval ring*, (*b*) a *spindle*, and (*c*) a *socket*.

(*a*) The *oval ring* should extend from the occiput behind to the tip of the chin in front. In width it is slightly wider than the distance between the angles of the jaw. It is hinged at the angle of the jaw at one side to open in a horizontal plane, and on the opposite side at the same point is fastened when closed by a ring clasp. It is made of one-quarter of an inch spring steel.

The antero-posterior diameter is from just below the occipital protuberance to the tip of the chin; the lateral diameter is the width between the angles of the jaw, to which should be added one-half of an inch or less on each side.

At the anterior end of the oval ring there should be a plate of hard rubber or celluloid moulded to the shape of the chin. This is riveted to a sheet-tin bridge, three-quarters of an inch in width and one and one-quarter inches long, soldered to the front of the ring. An occipital pad is required of hard rubber or thick leather, fastened to the inside of the posterior part of the ring and slanting backward to give support to the occiput. This pad, made of sheet steel covered with leather, should be approximately shaped to the contour of the back of the head. To the middle of the back of the ring is riveted a piece of steel sufficiently thick to be pierced with a vertical hole, into which is inserted the top of the spindle which connects the ring with the top of the brace and permits horizontal rotation.

(*b*) *Spindle.*—The steel spindle which connects the ring with the brace below fits into a socket riveted to the two uprights of the brace. The spindle should be bent in such an antero-posterior curve that when the brace is applied the oval ring should touch the occiput and chin at a proper angle. The spindle is prevented from dropping down in the socket of the brace by a set screw passing through the back half of the socket. By the use of this screw the spindle may be raised or lowered as desired.

The length of the spindle is a distance from a point just below the occipital protuberance to the point on the uprights selected for the socket. The spindle is forged from three-eighths of an inch machine steel, and in its lower part is one-quarter of an inch wide and thick, being flattened on the anterior surface and curved on the posterior. In

its upper third it becomes circular, and terminates above in a vertical, circular pin, one-sixteenth of an inch in diameter, fitting accurately into the socket at the back of the oval ring. As a guide to the shape of the spindle, a tracing should be taken with a strip of lead in the middle line at the back, running from the occiput to the point where the socket is to be attached to the uprights.

(*c*) *Socket.*—The socket consists of a flat steel bar, riveted at each end to the uprights of the brace. In the middle it is sufficiently thick to allow a hole to be drilled in it from above downward, through which passes the lower part of the spindle. This piece, of machine steel, should be one-half of an inch wide and three-quarters of an inch thick. The dimensions of the hole for the spindle are the same as those given for the lower part of the spindle, which fits closely into the hole. The spindle is prevented from slipping down by two set screws, which turn in threads drilled in the posterior half of the socket where the spindle passes through. The parts described are finished in the same way as the rest of the brace.

6. ANTERIOR HEAD SUPPORT.

The anterior head support is to be attached to the antero-posterior support or the plaster jacket. It consists of (*a*, *b*) *two pieces of wire*, and (*c*) an *occipital piece of steel.*

(*a*) The chest and shoulder piece is a U-shaped piece of wire bent to rest on the shoulders and on the chest, not bearing on the clavicles.

The U-piece which is applied to the chest and shoulders is measured from the level of the xiphoid cartilage to one inch posterior to the anterior border of the trapezius. These strips are vertical. The width of the bottom of the U-piece is the horizontal distance between the middle of the clavicles. It is bent to follow the lateral contour of the chest, and from below upward lies closely against the chest and shoulders, but is bent out over the clavicles.

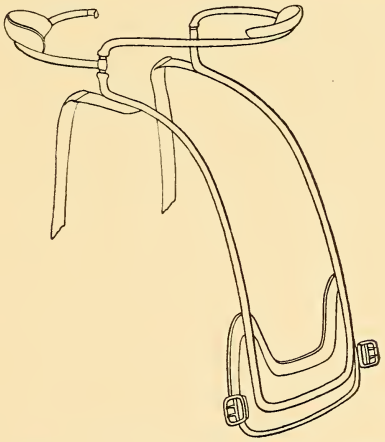


FIG. 551.—Anterior Head Support. (See Fig. 77.)

(*b*) The other piece of wire, the chin-piece, is bent to follow the outline of the chin and the ramus of the jaw. The posterior ends of the chin-piece are bent vertically downward just back of the ramus of the jaw, and welded or soldered to the chest-piece at points posterior to the clavicle on each side.

(*c*) The occipital piece consists of a strip of cast steel wire, one-quarter of an inch thick, running horizontally behind the head and bent around the wire upright on one side to form a hinge and secured to the opposite wire upright by a hook catch made by bending over its end.

The length of the anterior horizontal portion is the distance from just behind the ramus of the jaw to the tip of the chin. Its width is the distance between the outer surface of the mastoid processes plus one-half of an inch or less on each side. The height of the vertical portion of the chin-piece, where its posterior ends are bent down to unite with the shoulder-piece, is measured from the tip of the ear to the point where the highest portion of the shoulder-piece passes over the shoulder. This vertical portion slopes outward from the ramus of the jaw to the shoulder part of the U-piece. The measure of the occipital part of the brace is the distance between the tips of the ears measured as a curve, not touching the skin, at a level just below the occipital protuberance.

To prevent chafing of the skin, pads are attached under the tip of the chin, as described in the oval ring. The occipital piece is padded behind with thick felt covered with leather. To the portions of the U-piece of the brace passing over the shoulder and across the sternum are soldered strips of thick machine steel, three-quarters of an inch wide and one-quarter of an inch thick, curved to fit the brace, perforated at their edges with small holes, so that there may be stitched to the posterior surface of these steel pieces felt pads covered with chamois or kid. The material used for constructing this head-piece is cast steel, one-quarter of an inch in diameter.

The support is fastened to the back brace by means of strips of webbing, one inch wide, riveted to the upper part of the U-piece. These straps, which should be padded, pass over the shoulders and are fastened to buckles riveted to the upper ends of the antero-posterior support. Similar webbing straps are also attached to the lower angles of the U-piece and pass horizontally around the sides of the chest, to be fastened to buckles attached to the middle of the antero-posterior support.

If it is desired to give greater security to the head, upright strips of steel may be attached to the posterior part of either of the forms of support just described, the oval ring or the antero-posterior support. These strips are bent to conform to the posterior contour of the head, and pass upward one inch behind the mastoid processes to the level of the parietal eminences. They are made of spring steel, one and one-quarter inches wide and one-sixteenth of an inch thick, forming a padded plate at the top riveted on to the upright. The length of the upright, made of one-quarter of an inch round cast steel, is the distance from the horizontal ring to the parietal eminence. They are provided

at their upper ends with buckles, which are riveted to them, which serve to secure a padded webbing strap passing forward round the forehead from one upright to the other. They are also provided at the level of the mastoid processes with a buckle facing inward on each upright, which serves to secure a supporting strap passing behind the occiput. The tightening of these straps steadies the head, and, with the chin-piece, holds it firmly.

7. THOMAS COLLAR.

The original Thomas collar consisted of a strip of calf skin folded on itself to the depth of from four to six inches, the two free ends being stitched together in an irregular curved line. In the centre of the portion to be placed under the chin the stitching was from four to six inches below the upper border. At the point below the ear the stitching was two inches from the upper border. At the posterior portion the lower border of the stitching was three inches below the upper border. Sawdust was pressed in between the folds of leather held below by the stitching and above by the folded top of the leather. Straps and buckles were attached to the posterior portion of the collar stitched around the neck. A greater or less amount of sawdust was packed into the cavity, in order to increase or diminish the amount of support. This collar, which can be made by any saddler, is somewhat awkward in shape but readily made. As a substitute for this, a collar stock can be made of stiffened leather similar to what is used for leather jackets, reinforced by steel or phosphor bronze and padded with felt. The length of the collar or stock should be sufficient to encircle the neck and fasten behind without overlapping.

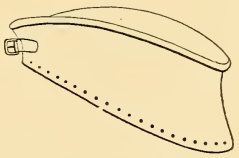


FIG. 552.—Thomas Collar. (See Fig. 78.)

8. QUADRILATERAL BACK BRACE.[1]

The design of this brace is to combine with the antero-posterior leverage action of the Taylor back brace the power of checking rotation obtained in the plaster-of-Paris jacket. The entire upper chest is left free from the pressure of the apron, and the shoulder girdle is used as a point of counter-pressure for the axillary straps. This is made possible by the fastening of the scapulæ under the widely separated uprights, which restrict their motion upon the thorax within very narrow limits. It consists of (*a*) a pelvic band; (*b*) two uprights; (*c*) a top bar; (*d*) a pad plate bar; (*e*) an apron.

[1] John Dane: Trans. Am. Orth. Assn., xiii., 70.

(*a*) The *pelvic band* is made of No. 15 gauge sheet steel, and is bent to fit the curve of the pelvis, circling it behind at a point just above the trochanters. Its anterior ends reach to the anterior superior spines.

(*b*) The *uprights*, made of No. 12 gauge cast steel, and riveted to the pelvic band a little outside of the posterior superior spines. They extend upward to one-half of an inch above the spines of the scapulæ. To their ends are riveted the descending arms of the top bar. These uprights are bent so as to follow the curve of the flanks, but not to rest upon the skin until they pass over the scapulæ, from which point they should press upon the skin when the shoulder-straps are tightened.

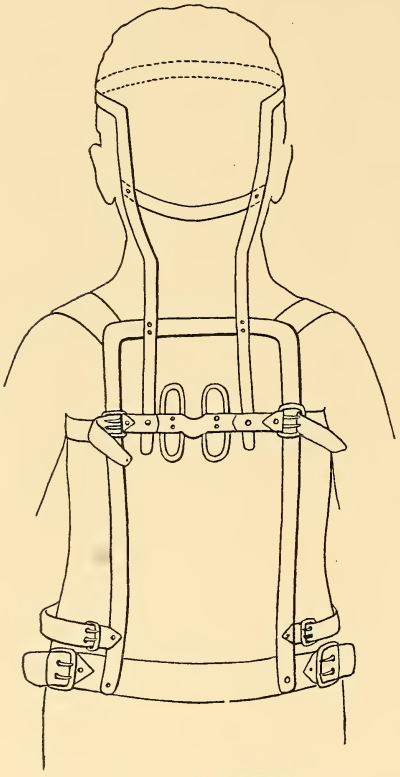


FIG. 553.—Quadrilateral Back Brace.

(*c*) *The Top Bar.*—This is made of the same size of metal as the uprights. Its length is the diameter of the back, taken from one-half of an inch inside the glenoid rim of the scapulæ, when the shoulders are pulled backward. Each end of this bar is bent at a right angle downward and continued for one inch. To these descending arms the upper extremities of the uprights are riveted.

(*d*) *The Pad-Plate Bar.*—This is a horizontal bar, No. 14 gauge sheet steel, fastened to the uprights by means of a flat-headed screw at the level of the kyphos. Its central portion is curved sharply backward so as to clear the spinous process of the vertebræ. On the slope of this curve on each side are riveted the *pad plates*. These are flat strips of No. 18 gauge sheet steel, one-half of an inch wide and from one and one-half to three inches long. The distance between them is enough to insure their pressure falling upon the transverse processes of the vertebræ. To facilitate adjustment of the pad-plate bar the opening for the screws that hold its ends to the uprights is made in the form of slits, one-half of an inch in length.

Three buckles are riveted to the uprights, one on each side, the upper one just below the axilla, the others equally spaced below. One more pair of buckles are riveted to the ends of the pelvic band. One

end of a padded strap is riveted to the outer end of the top bar on each side.

The frame of the brace is wound with canton flannel or covered on the side next the skin with leather. Each pad plate has a felt pad, three-eighths of an inch thick, sewed to its anterior surface. These can be frequently changed as occasion may arise.

(*e*) *The Apron.*—This is cut from sole leather, one-sixteenth of an inch thick. Its length extends from the level of the ensiform to the top of the pubis in the median line; from the level of the ensiform to the anterior superior spines on the sides. Its width is the diameter between the anterior spines. Straps of webbing are sewed to this on each side opposite the lower buckles on the brace, the upper pair of buckles taking the ends of the padded straps that come from the top bar of the brace.

Quadrilateral Back Brace with Head Support.

The brace is similar to that just described, with the addition of a second horizontal bar connecting the uprights from one to two inches below the top bar. In cases of very high deformity the pad-plate bar can be made to take its place.

The head support consists of: (*a*) Two uprights; (*b*) the occipital strap; (*c*) the frontal strap.

(*a*) The *uprights.* Starting as flat forged steel bars, one-half of an inch wide and one-eighth of an inch thick, from one inch below the second horizontal bar, they are carried straight upward to a point one inch below the occiput; then as round rods they are curved upward and outward to a point one inch above and one-half of an inch behind the ear; then forward close to the head as flat bars to the level of the posterior part of the forehead. As they pass around the occiput behind they are one-half of an inch from the head. These uprights pass through guides riveted to the posterior surface of the top and second bars of the brace. The guides on the second bar are perforated with holes and finished with screws for holding the uprights in position. The width between the guides should be a little less than the transverse diameter of the patient's neck. The horizontal flanges are covered with leather on their inner sides where they grasp the head. A buckle is riveted to the anterior end of each horizontal flange.

(*b*) The *occipital strap* is made of a thin strip of brass, one-quarter of an inch wide, covered with calf-skin. On one end it is prolonged forward for one-half of an inch as a right-angled arm. This is riveted to one of the uprights at the angle where it becomes horizontal. Its other end is free. This strap is padded on its inner side with thin felt and covered with leather. On the free end this leather is prolonged as

a strap and passes through a buckle riveted to the outer side of the other upright at the angle where that becomes horizontal.

(*c*) The *frontal strap* is made of calf-skin, one inch wide where it crosses the forehead, rapidly tapering to the diameter of the buckles that have been riveted to the horizontal arms of the uprights. Each end of this strap is punched with a series of holes for the tongue of the corresponding buckle.

9. THE GAS-PIPE BED FRAME.

The gas-pipe bed frame is of a rectangular form and is made of ordinary gas pipe, the size of the gas pipe being governed by the size and weight of the patient. What is known as "quarter-inch" pipe is sufficiently large for children, and three-eighths of an inch pipe for adults of moderate weight.

Four pieces of gas pipe are threaded at their ends for one inch, and are attached to each other at the four corners by four elbows. The

FIG. 554.—Gas-Pipe Frame.

length of the frame is the height of the patient, with the addition of four inches. The width of the frame is the distance between the axillary lines or a little less. The frame is covered with stout cotton cloth, generally doubled. This cover should be a little short of the full length of the frame and one and three-quarters times as wide. This passes over the front of the frame and around its sides, and is secured behind by webbing and buckles, which are sewed to its under side at proper intervals or is laced by a cord stitched through the edges by means of a sailor's needle. To protect the cover from wrinkling two tapes are run from the top and two from the bottom of the cover to the top and bottom of the frame. The cover should be smoothly stretched on the frame and should lie without wrinkling. When the patient must not be lifted for the use of the bed pan, the covering is opened by two cuts intersecting at a right angle opposite the pelvis. The cut flaps are sewed back to the back part of the covering, and the borders of the cover at the hole are protected by rubber sheeting. The cover is easily renewed when stretched or soiled. In heavy patients, to prevent the sides of the frame from being pulled together, they are braced apart by a flat strip of machine steel, three-quarters of

an inch wide and one-quarter of an inch thick. This strip is bent at the ends to hook over the pipe at the sides of the frame.

If it is desired to hold the spine in a position of hyperextension, the sides of the bed frame may be curved upward opposite the deformity to any desired extent. This curve may be a gradual one or a section of the frame may be elevated by an abrupt curve above and below it.

10. TRACTION HIP SPLINT.

The traction hip splint consists of: (*a*) A horizontal pelvic band; (*b*) an outside upright; and (*c*) two or three posterior bands behind the thigh and calf.

(*a*) The *pelvic band* is made of one piece of flat steel curved in the shape of a U, which passes along the front of the pelvis, around the side on which is situated the diseased hip, and then passes along the posterior surface of the pelvis. The anterior part of the pelvic band forms a curved right angle with the outer surface of the band, which is somewhat flattened, but where the outer part of the band joins the posterior part the angular curve is rounded and is not so sharp as at the anterior angle. The measurements of the pelvic band are as follows: The anterior half extends from the point at the middle of the outside of the thigh just above the trochanter to a point just beyond the opposite anterior superior spine of the ilium. The posterior half is one inch longer than the anterior half, and is bent in a more gradual curve, as has been said. The pelvic band is made of tire steel, No. 8 gauge, and one inch wide. It is forged so that the anterior and posterior parts are parallel to each other in the vertical plane, and the free ends are rounded. The pelvic band is fastened to the upright at an inclination of twenty degrees from a right angle, the posterior part being higher than the anterior. The anterior and posterior arms of the pelvic band should be separated by a distance of one inch greater than the antero-posterior distance between the anterior and posterior superior iliac spines. The pelvic band should form a right angle in the lateral plane with the upright.

Buckles are placed on the pelvic band, two in front and two behind, to hold the perineal bands which furnish counter-traction to the extension pull downward. At the back they are situated just posteriorly to the trochanters, one on each side. The perineal bands pass forward at the side of the perineum to buckle on the anterior arm, one at each side of the median line. These buckles should be placed as close together in front as is possible without interfering with the genitals. Another buckle is fastened to the anterior end of the pelvic band, to which is fastened a strap passing from the posterior end. The pelvic band is padded on the inside with a strip of felt and covered with

leather stitched at the edges. The inside of the band should be covered with sheep-skin and the outside with morocco leather or calf-skin. The buckles are riveted on through the leather and are on the outside of it. The leather which covers the pelvic band is made long enough to pass beyond the end of the posterior arm of the splint, and, passing around the outside of the pelvis of the patient, is buckled into the

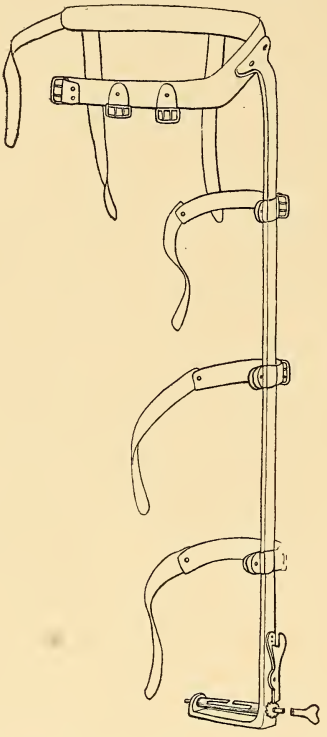


FIG. 555.—Long Traction Hip Splint. (See Figs. 119 and 122.)

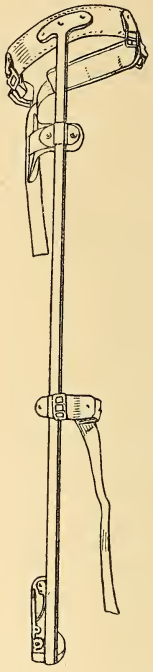


FIG. 556.—Side View of the Long Traction Appliance.

buckle on the anterior arm of the pelvic band. This may be done by means of a webbing strap, seven-eighths of an inch wide, passing into a seven-eighths-of-an-inch buckle, or by means of a strap of leather riveted to the leather of the pelvic band. This leather strap should be one and one-quarter inches wide. The upright is finished by being nickel-plated, blued, or japanned.

(*b*) The *upright* runs on the outside of the leg, from a point on a level with the anterior superior spine of the ilium to a point two and one-half inches below the bare heel. It should be straight, except in the case of very fat patients, when it should bend outward in its upper third to follow the curve of the hip. The bottom of the upright is flattened from side to side for a distance of three and one-eighth inches. After being flattened at this point it should measure five-eighths

of an inch wide and one-quarter of an inch thick. It is then turned in at a sharp right angle to the upright for a distance of two and one-half inches, and the part coming next to the ground is forged flat. After running inward at a right angle to the upright for two and one-half inches, the extreme end is turned up at a right angle, running up from the bottom of the foot-piece where it touches the ground a distance of five-eighths of an inch. This constitutes the bottom piece of the splint, to which a windlass arrangement is attached. This consists of a spindle, three inches long and one-quarter of an inch in diameter, passing through holes drilled in the upright at a point one-half of an inch from the bottom of the splint to a corresponding hole in the turn of the inner part of the foot-piece. This spindle is fastened in place by a pin passing through it on the outside of the part projecting up from the inside of the foot-piece. It projects beyond the outer surface of the upright for a distance of three-eighths of an inch. Next to the upright and outside of it is fastened upon the spindle a ratchet wheel, one-half of an inch in diameter, which is controlled by a spring and stop, one and one-eighth inches in length, fastened to the upright above it by a pin. The end of the spindle terminates in a square end-piece fitted to a clock key. By means of this attachment it can be turned only in one direction. The spindle is partially split at its middle for the insertion of webbing straps.

The upright at its top is fastened to the pelvic band in one of two ways. In small children, where there is not very much strain, the upper end of the upright is flattened out, forming an angle of twenty degrees with the upright and curved to lie close to the pelvic band. In its flattened part three holes are drilled, and corresponding to them three holes are drilled in the pelvic band, and by means of these holes the pelvic band is fastened to the upright by three strong one-eighth-of-an-inch rivets. For large patients, where greater strain is liable, a stronger connection is necessary. In this case a heavy pelvic band is necessary, and the upright is not flattened at its top but is left square. A short steel strip is then forged in such a way that it passes along the pelvic band in front of the upright for a distance of one inch. It then curves out and round the upright and back to the pelvic band, which it follows for one inch posterior to the upright. In front of the upright and back of it holes are drilled in this strip, and holes are drilled in the pelvic band opposite to them, through which stout rivets are passed. A hole is also drilled through the strip of steel passing outside the upright, through the upright, and through the pelvic band, and through this hole another rivet is passed, contributing greater stability. The upright should be made of one-inch quadrilateral machine steel. If the child is not to walk in the splint, a piece of quadrilateral steel, three-eighths of an inch in diameter, may be used.

(*c*) *Posterior Bands.*—To fasten the leg to the splint, two or three posterior curved bands are necessary. In young children two are sufficient; in older children and adults three are necessary. If two bands are used, one should be placed below the middle of the thigh and the other at the upper third of the calf. If three bands are used, one is placed above the middle of the thigh, one at the lower part of the thigh, and one at the upper third of the calf. The circumference of these bands should be half the circumference of the thigh or leg at a corresponding level. The curve should form the posterior half of a circle

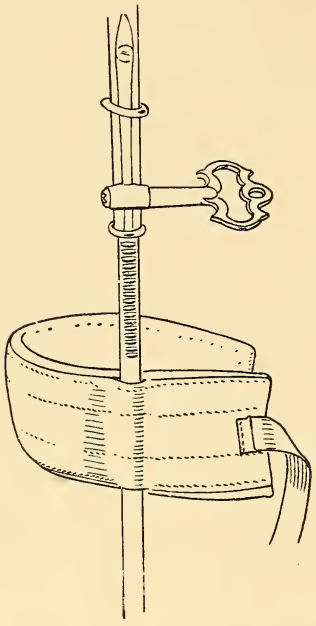


FIG. 557.—Apparatus for Extension. (Fiske Prize Fund Essay.)

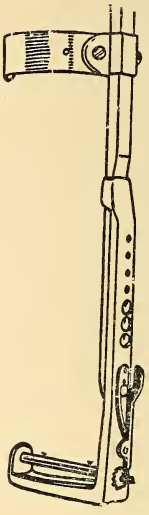


FIG. 558.—Windlass and Ratchet Appliance for Extension. (Fiske Prize Fund Essay.)

and should be made of sheet steel of No. 14 gauge and one inch wide. They are fastened to the inner side of the upright and should project one-half of an inch beyond the anterior edge of the upright. By means of an arrangement similar to that described for fastening the pelvic band to the upright in heavy patients, these are fastened to the upright, except that no rivet is passed through the upright and that screws instead of rivets are used to fasten the two ends of the encircling piece of steel to the calf or thigh band. By tightening these screws the curved band is fastened firmly in place, and by loosening the screws it can be moved up and down on the upright.

The calf bands are padded on the anterior surface with felt and covered with calf or ooze leather stitched on the edges. On the inner end of each curved band a webbing strap is riveted, to pass around the front of the leg and fasten into a buckle, riveted on the end of the calf or leg band close to the splint.

Perineal Bands.—Perineal bands are made of webbing padded in their middle half by felt covered with canton flannel, or they are made of leather padded with felt and covered with moose hide. The covering of the perineal bands should be stitched together on the under side of the strap, so that the stitching will not come in contact with the skin of the perineum where pressure would make it uncomfortable.

11. CONVALESCENT HIP SPLINT.

The traction hip splint may be changed to a protection splint suitable for use in convalescence as follows: Instead of ending below in the traction foot-piece described above, the upright is cut three inches above the lower end, and there is welded to the upright a piece long enough to extend two inches below the sole of the foot, which below is

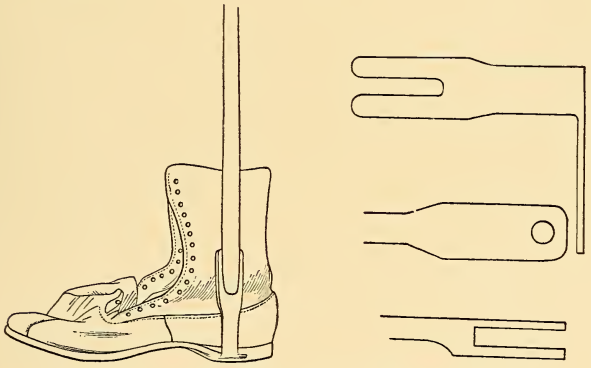


FIG. 559.—Detail of Foot-piece of Convalescent Hip Splint.

expanded into a bulbous tip, three-quarters of an inch in diameter, containing in its centre a hole, in which is inserted a plug of rubber, which is fastened into the bottom of the foot-piece.

This crutch tip serves to receive the impact of the weight in walking, and should be of such a length that, while the ball of the foot may be used in walking, the heel is prevented from touching the ground. The length of the upright under these conditions should be the distance from the anterior superior spine of the ilium to the bottom of the heel of the shoe, when the foot is at a right angle, plus one to one and one-half inches. In case it is desired to have the splint made so that its length may be adjusted to the growth of the child, this may be done

by cutting off the lower end of the upright at a distance of three inches from its normal length. This part is then forged flat on its outer surface for a distance of three and a half inches, and is rounded on its inner and threaded for screws by holes one-half of an inch apart.

The part of the upright carrying the foot-piece is flattened at its upper two-thirds and lies on the outside of the lower part of the upright.

The end of the lower piece is drawn out to form two clips curving inward, which embrace between them the lower end of the upright, three and one-half inches above where it is cut off. Holes are drilled in both uprights and threaded for screws one-quarter of an inch in diameter. By means of screws passing through these holes, the extension piece may be fastened to the upright at any desired level.

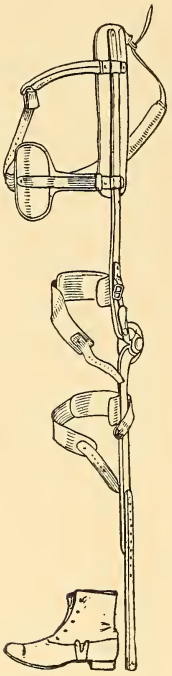


FIG. 560.—Convalescent Hip Splint. (See Figs. 128 and 129.)

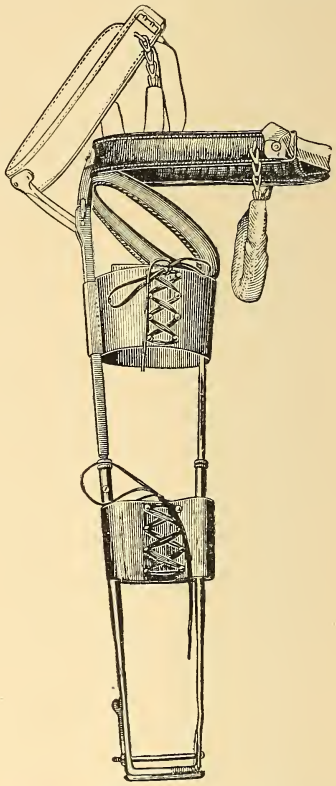


FIG. 561.—Modified Hip Splint. (Dane.) (See Fig. 123.)

In the case of adults and older children, it is desirable that the convalescent splint should be jointed at the knee. This joint should be situated opposite the inner condyle of the femur. Of the various forms of joint in use those shown in the diagrams will be most serviceable. The illustrations will show their construction.

12. THE DOUBLE UPRIGHT HIP SPLINT.[1]

The special object of this form of hip splint is to furnish a firmer grasp upon the pelvis, and, when converted to the convalescent type, to transfer the support in walking to a point nearer the median line of the body. Its lower portion is similar to the Thomas knee splint, with the exception that the outer upright is made somewhat heavier and is prolonged above the ring for about one inch. The lower ends of the uprights are also furnished with some device for making traction, either in the form of a windlass or simply a pair of buckles. The pelvic portion of the splint is similar to that of the long traction hip splint, with the addition of a second posterior pelvic arm. The lower pelvic arm is carried as far down as possible over the sacrum; the upper follows closely under the curve made by the crests of the ilia. Each of these arms is prolonged around the opposite or sound side of the pelvis by means of a strip of No. 20 gauge steel, one-sixteenth of an inch thick, riveted to its free extremity. To these in turn are riveted the outer ends of the webbing straps, which complete the circuit by passing through two buckles, one at the extremity, the second three inches farther along on the single rigid anterior arm. The padding consists of a thick piece of leather, a little wider than the pelvic arms, riveted firmly on the inside to them and their flexible extensions. This leather is free only as a flap under the space occupied by the straps and buckles. The single perineal strap, which passes through the groin on the sound side, is made of "window-chain" padded with felt, riveted to the lower pelvic arm behind and hooking over a bent staple riveted near the outer extremity of the anterior arm.

13. THOMAS HIP SPLINT.

The Thomas hip splint consists of: (*a*) an upright; (*b*) a chest band; (*c*) a thigh band; and (*d*) a calf band.

(*a*) The *upright* runs vertically at one side of the patient's back and follows the line of the diseased leg. It reaches from the lower angle of the scapula to the junction of the middle and lower third of the leg, passing posteriorly to the hip-joint. It is bent in two places—one opposite the fold of the buttock, and the other just above the hip-joint, so that the leg portion and body portion follow parallel lines, distant from each other from one-half to two inches, the leg-piece lying in a plane somewhat anterior to the body-piece. The bends should be round rather than angular. From the fold of the buttock to the lower end of the spine the leg portion is perfectly straight, as is also the upper portion of the splint from the bend opposite the joint to its upper end.

[1] John Dane: Trans. Am. Orth. Assn., x., 233; xiv., 74.

The upright is usually twisted somewhat in its longitudinal axis, so that the body portion lies slightly to the side and flat against the curved outline of the chest, while the leg portion lies directly posterior to the middle line of the leg. The buttock bend lies between the great trochanter and the tuberosity of the ischium. The upright for a child of ten should measure three-quarters to three-sixteenths of an inch, and is made of the softest and toughest iron available. Annealed steel is not the material to use.

(*b*) The *chest-piece* is made of flat bar iron, which varies in width and thickness in proportion to the patient. It should be long enough to encircle the chest, leaving a gap between its ends of one or two inches. It is joined to the uprights at a distance of one or two inches to the side of its middle point, the shorter wing encircling the chest on the side of the disease. The relative length of the two wings of the chest-piece may be determined by measuring from the lower angle of the scapula on the diseased side round each side of the chest to the point in front where it is intended that the piece should terminate. The upper end of the main upright is forged flat and bent over the chest-piece, and the two are made fast by a single rivet. In each end of the chest-piece, which is flattened for the purpose, a hole, three-quarters of an inch in diameter, is drilled for the fastening of the shoulder bandage. The chest-piece and the upright form a right angle with each other.

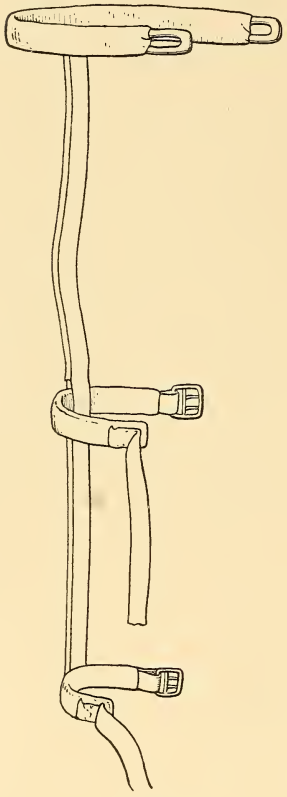


FIG. 562.

FIG. 563.

FIG. 562.—Thomas Hip Splint Covered and Provided with Straps.

FIG. 563.—Diagrammatic Outline. Parallelism of body and leg portions. (Ridlon.)

(*c*) The *thigh band* is made of flat bar iron of about the same size as the upright, and is fastened to the inner surface of the upright by one rivet, at a point about one inch below the lower bend of the upright. The thigh band should be riveted to the upright so that its inner portion is one inch or more longer than the outer.

(*d*) The *calf band* is made of flat bar iron, and is joined to the lower end of the upright by a single rivet in the same manner and in the same relative position as the thigh band. The inner surface of the splint next to the patient is covered with harness-makers' felt or ordinary boiler felting, about one-quarter of an inch in thickness. The whole is then covered with basil leather, a variety of sheep-skin, which is put on wet and snugly stitched into place. This shrinks when it dries, which will prevent any slipping of the cover of the splint.

The final adjustment of the splint is made by means of wrenches until the bands fit closely to the leg and chest. Another piece of bandage is wound around the splint and leg at its lower extremity, and pinned securely to an anterior piece wound around the thigh above the knee. Shoulder-straps pass from the top of the upright over the shoulders to the anterior ends of the splint.[1]

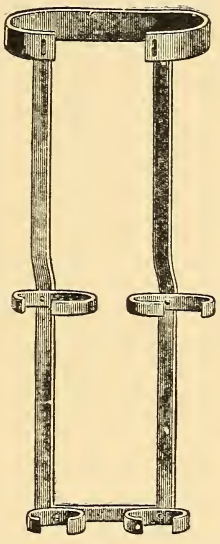


FIG. 564.

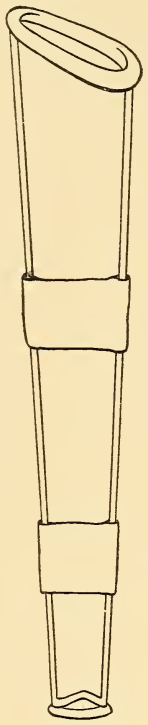


FIG. 565.

FIG. 564.—Thomas Hip Splint, Double. (Ridlon.)
FIG. 565.—Thomas Knee Splint with Ring Covered and Posterior Leather Attached.

14. THOMAS KNEE SPLINT.

The Thomas knee splint consists of: (*a*) a perineal ring; (*b*) two uprights; and (*c*) a bottom plate.

(*a*) The *ring* is made of round steel wire, one-quarter of an inch in diameter for a child of ten years, increasing to one-half of an inch for use in adults. The ring is an irregular ovoid, flattened in front and turned out at the posterior and inner portion of the thigh. It slopes from without inward and from before backward. It is fastened to the inner upright at an angle of one hundred and thirty-five degrees, and in the anterior plane the ring forms with the inner bar an angle of about one hundred and forty-five degrees. In making the ring the ends should be joined by welding in preference to brazing. The anterior surface of the ring is made flat on account of the flatness of the groin, its posterior part is expanded to accommodate the thickness of the buttock, and the antero-posterior tilt is to enable the patient to rest comfortably on the ring

[1] Ridlon and Jones: "Chronic Joint Disease," p. 106, 1894.

with the tuberosity of the ischium. The measurement of the ring is the oblique circumference of the thigh taken as high up as possible at an angle of about one hundred and thirty-five degrees to the long axis of the leg. To this measure an inch is added to allow for the padding.

(*b*) The *uprights* are made of five-sixteenth steel wire. The inner bar is welded to the upright at the angle mentioned. The other rod is fastened to the ring slightly farther back than the outer rod. The bottom of the rod should come two inches below the sole of the bare foot.

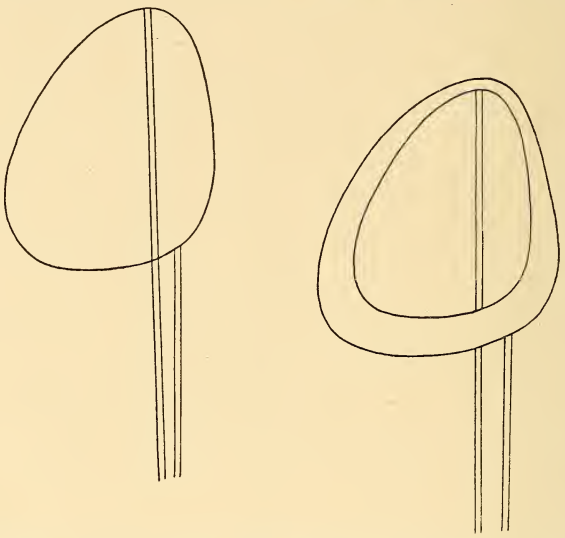


FIG. 566.—Side View of Ring of Thomas Knee Splint Uncovered and Covered, Showing Proper Shape. (Drawn from Ridlon and Jones.)

As originally made by Mr. Thomas, the splint simply terminated in a loop where the inside upright was bent round below the foot to return as the outside upright.

(*c*) *The Bottom Plate.*—For use in walking, however, some form of foot plate is necessary. For the more acute cases it is convenient to weld to the bottom of the uprights a base plate or patten, oval or round in shape, three inches in diameter, with a hole one and one-half inches in diameter in its centre. This is made of an ordinary iron washer, one-quarter of an inch in thickness. It should be perforated by two or more holes, in order that a piece of leather may be riveted to the under side for walking.[1]

Measurement.—The length of the inner upright is the distance from the tuberosity of the ischium to the sole of the foot plus two or more

[1] At the Hospital for the Ruptured and Crippled in New York there is in use an arrangement for protecting the bottom of the splint in which the uprights terminate below in a cross bar, which is put through a section of rubber carriage tire, forming an efficient and inexpensive foot-piece.

inches. The required width at the knee and ankle should be given in order that the bars may clear the side of the limb.

Padding.—The ring is padded with boiler felting for a thickness of about one-half of an inch on its outer portion and from one to one and one-half inches in thickness on its inner posterior portion. This is then covered with basil leather or a tanned sheep-skin put on wet and sewed after the manner of the harness-maker along the lower and outer border of the ring, where the seam will not chafe the patient.[1] Two strips of basil leather, about three inches in width, are sewed at one end round one of the side bars, the other end being left free and of sufficient length to be drawn across to the opposite bar, and when sewed there to form a support for the back of the limb when the splint is applied. One of these straps is to be placed at the back of the knee, or above it if the knee is too sensitive, and the other at the back of the ankle. When the splint is applied the leg is fastened to it by means of a roller bandage carried to and fro around the upright and fastening in front of the leg just above the knee, where it passes over a thick pad of metal or of leather placed in front of the lower end of the thigh. A roll of bandage is also fastened in the same manner over an anterior pad placed in front just below the knee.

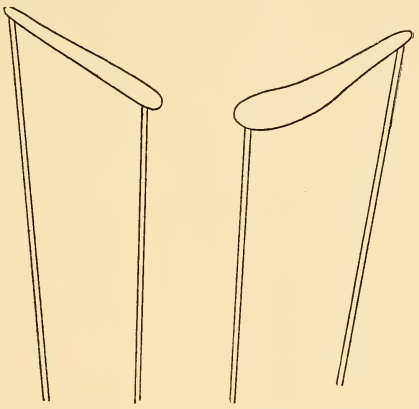


FIG. 567.—View of Front and Back of Ring of Thomas Knee Splint Covered, Showing Depression at Back for Tuberosity of Ischium. (Drawn from Ridlon and Jones.)

15. THOMAS CALIPER SPLINT.

In cases which are not sufficiently acute to require the use of the plate attached below the foot, the lower ends of the inner and upper bars may be turned sharply inward at a right angle at a point one inch below the bottom of the heel of the boot.[2] The measurement for this may be taken by applying the unfinished splint in its proper relation and marking on the upright the place where the bend should occur, or the distance may be measured from the tuberosity of the ischium to a point one inch below the bottom of the sole of the boot. The splint is then fastened to the boot by means of a hole drilled through the heel from side to side, into which a steel tube is inserted, of a proper calibre

[1] Ridlon and Jones: "Chronic Joint Disease," Chicago, 1894.

[2] See Fig. 577 for detail of foot-piece.

to accommodate the ends of the splint. The bends in the ends of the splint, which should each be three-quarters of an inch long, are passed into this tube and are held together by the leather straps above mentioned. In the use of this splint a triangular piece should be cut away from the back of the shoe and a loose piece of leather sewed on over it. This triangle, with its apex upward, should begin well above the counter of the shoe, and at its base should be as wide as the width of the heel. In this way excoriation of the heel can be avoided. The splint may be finished by being blued or japanned.

16. JOINTED KNEE SPLINT.

This apparatus consists of (*a*) two uprights; (*b*) an arm for perineal band; (*c*) a foot-piece; and (*d*) two posterior bands for the thigh and one for the calf.

It is intended to serve as an apparatus for fixing the knee at any angle and for making traction upon it if desired. It also furnishes protection from weight-bearing in walking.

(*a*) *Uprights.*—The outside upright reaches from the level of the trochanter at the top to two and one-half inches below the sole of the bare foot below. It is constructed of flat machine steel, five-eighths of an inch thick. The outside is constructed in two parts, which are joined together opposite the inner condyle of the femur to make a joint. This joint may be left movable or may be fastened at any angle. The two ends of the upright which form this joint are flattened into discs, the centre of which is drilled for a hole for the formation of the joint. The two discs where they come in contact are ground flat, and a disc of flat steel, two inches in diameter, is placed over the inner surface of the joint. Through a hole drilled in its centre a rivet is passed binding the three pieces together, forming an antero-posterior joint. This joint should lie somewhat back of the plane of the uprights, and for this purpose the ends of the uprights which are to form the joint are bent back on the flat about one and one-half inches. This joint is set at any desired angle by means of a set screw passing through the upper end of the lower half of the upright, passing into holes drilled in the steel disc one-half of an inch apart. This plate should be oblong in shape, about two inches wide and three or four inches in length.

The inner upright runs on the inside of the leg from a point one or two inches below the perineum to the bottom piece. It is lighter than the outside upright, and the two pieces of the upper and lower parts are joined together opposite the inner condyle of the femur by a simple antero-posterior joint.

(*b*) The *arm* for the perineal bands consists of an anterior portion, a vertical portion, and a horizontal posterior portion curved to fit the

pelvis. The anterior arm reaches from the top of the upright, curving forward and slightly downward to a point just inside the origin of the adductor tendons. The vertical portion of the perineal arm rises in the line of the upright to just below the level of the posterior superior spine of the ilium. It then turns at a right angle backward, and runs, following the curve of the pelvis, to a point just below the posterior superior spine of the ilium. This arm is drilled at its front and back ends with holes, to which are fastened buckles to carry the perineal band. The perineal arm should be made of cast steel, five-eighths of an inch wide and one-quarter of an inch thick. The horizontal part of the perineal arm is curved to fit the outside of the upright where it crosses it and is riveted to it. A steel pad, shaped to fit the contour of the hip, is placed inside of the upper end of the outside upright. This plate should be oblong in shape, about two inches wide and three or four inches in length.

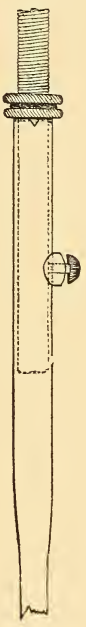


FIG. 568.

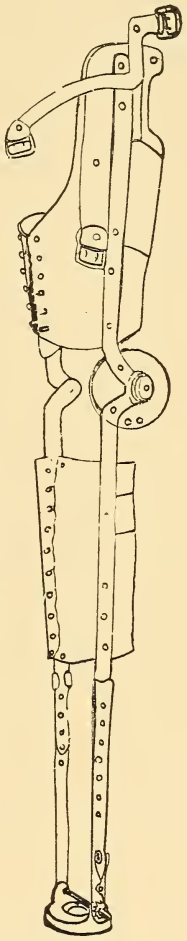


FIG. 569.

FIG. 568.—Application for Adjusting the Length of the Thomas Knee Splint. (Burrell.)

FIG. 569.—Splint for Traction on Knee at any Angle.

(*c*) *The Foot-Piece.*—The foot-piece of the splint, which connects with the outside and inside uprights or as a continuation of them, is furnished with the windlass traction apparatus described in speaking of the traction hip splint. This should come at a point one and one-half inches below the shank of the boot.

(*d*) The *posterior bands* are two in number, both semicircular in shape and convex backward to follow the contour of the leg and thigh. The arm passing back of the thigh is broadened at its upper end, and where it joins the outer upright is from one to two inches higher than where it joins the inner upright. It is fastened by rivets to the top of both uprights, and its upper edge should follow the line of the gluteal fold and should be well below it. This thigh-piece should be two inches wide at its inner end and three inches wide at its outer end, and should be made of No. 15 gauge sheet steel. The posterior calf band should encircle the calf at its upper third, being curved to fit it, and fastened

to the inside of both uprights at the proper point. It should be one inch in width.

Buckles should be fastened by rivets to the upper end of the inner upright and at a corresponding point on the outer upright to make upward traction if desired. Lacings of stout sole leather are fastened to the upright, lacing in front to encircle and steady the thigh and calf. They are furnished with studs for lacing, half an inch apart.

When the disease has become convalescent a movable joint, which can be stopped at any angle by a pin in the disc, may be substituted for the fixed joint, so that the patient can bend the knee in sitting. This type of joint has been described in speaking of the convalescent hip splint. At this stage also the traction arrangement of the foot-piece may be removed and the splint used as a protection splint, which can be bent at the knee when desired. In this case it is fastened to the boot in a manner similar to that described for the convalescent hip splint.

17. FIXATION ANKLE SPLINT.

In cases convalescent from ankle-joint disease, in which it is desired to prevent motion but which are sufficiently recovered to bear weight, a simple fixation splint may be substituted for the plaster-of-Paris bandage. This consists of (*a*) two uprights; (*b*) a foot-piece; and (*c*) a posterior calf band.

(*a*) The *uprights* run on the inside and on the outside of the leg from the bottom of the foot-piece to a point one inch below the tubercle of the tibia. They should be curved to fit the outline of the leg, but should be bent out so as not to touch the malleoli. They should be made of No. 10 gauge machine steel, one-half of an inch wide. One continuous piece of steel may be used, passing down the leg as the outside upright, being bent at a right angle to pass under the foot-piece and being turned up opposite the inner border of the foot-piece, to return up the leg as the inside upright.

(*b*) The *foot-piece* consists of a plate of cast steel, one-quarter of an inch thick, forged to the shape of the sole of the foot, extending in front to just behind the cleft between the toes and the foot. On the side it should be one-quarter of an inch narrower on each side than the whole width of the foot, and it should stop one-half of an inch in front of the back part of the os calcis. It should be curved to fit approximately the sole of the foot, and its inner surface should be slightly higher than the outer surface. It should be riveted to the piece of steel connecting the two uprights, passing across on its under surface at a point below the malleoli.

(*c*) The *posterior calf band* joins the two upper ends of the upright, and is curved backward to fit the posterior surface of the calf. It con-

sists of a piece of steel, one and one-eighth inches wide and No. 15 gauge, and is riveted to the upper inner surface of the two uprights. This band is padded with felt and covered with leather. A cuff of stout leather is riveted to the upright, following the contour of the calf and lacing in front. A piece of softer leather, cut like the upper of a low shoe, ending in front behind the metatarso-phalangeal joint of the great toe and with the part over the point of the heel cut away, is riveted by its under surface to the sole plate, to pass over the top of the foot, and laces down the middle line. It should be protected by a fly covering the junction of the two pieces, sewed to the inner side of one of them, and the edges of the leather pieces coming over the dorsum of the foot should be perforated for eyelets one-half of an inch apart. The posterior part of this foot lacing should be split in the vertical line behind and shortened sufficiently to set snugly back of the heel.

18. KNOCK-KNEE BRACE.

Measurements for knock-knee braces are given for a child of about the age of three.

Knock-knee braces consist of three parts: (*a*) an upright; (*b*) a foot-piece; and (*c*) two posterior bands.

(*a*) The *upright* is made of cast steel, five-eighths of an inch wide and one-eighth of an inch thick, and runs along the outer side of the leg from a point opposite the ankle-joint to a point one-half of an inch above the trochanter. The top of the upright from this point curves backward to a point just below the posterior superior spine of the ilium, following the contour of the buttock. The angle of the curve at the top of the upright is, of course, determined by the relative position of the two points given. The bottom part of the upright is flattened and enlarged, and its centre bored with a hole, one-quarter of an inch in diameter, through which is to pass the spindle of the ankle-joint.

(*b*) The *foot-piece* consists of a triangular piece of steel, nearly as wide as the boot at its back, and at the apex which comes in front it terminates in a rounded point. It should be approximately one and one-half inches long, and should be made of machine steel, one-quarter of an inch thick. It is fastened to the inside of the bottom of the boot by rivets, and from its inner border just below the upper malleolus there runs up from it a vertical arm of about the same size and width as the upright, to join the upright opposite the ankle-joint. It is curved so as to clear the outer border of the foot, and is joined to the bottom of the outside upright opposite the malleolus as a free joint moving in the antero-posterior plane. The inner surface of this joint lying next to the malleolus should be furnished with a circular pad of steel, about the size of a twenty-five-cent piece, padded with felt and covered with

leather to protect the outer malleolus from pressure. The top of the upright, where it bears on the side of the thigh, is furnished with a small pad.

(*c*) There should be riveted to the inner side of the upright two *semicircular posterior bands*, curved posteriorly, made of sheet steel, two inches wide, No. 17 gauge, which should cross the lower third of the thigh and the upper third of the calf. These points are connected by a strip of steel running from the middle of the upper one to the middle of the lower one in a vertical line. This steel should be one-half of an inch wide and one-eighth of an inch thick, and should be fastened to the posterior surfaces of the thigh and calf bands.

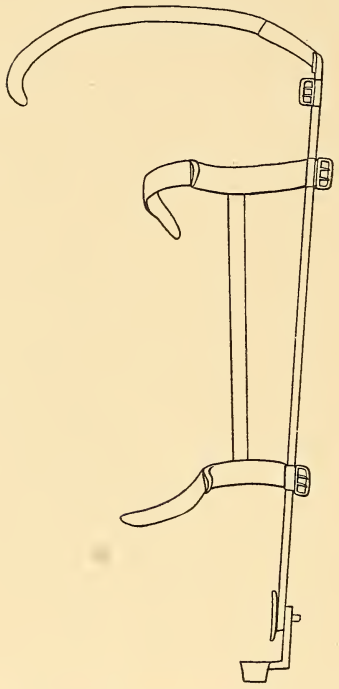


FIG. 570.—Knock-knee Brace.

There should be a buckle at the posterior end of the curved portion of the upright and another buckle on each side where the upright begins to bend upward and backward. The posterior buckles should be connected by a strap running behind the body, and the anterior buckles by a strap running in front. By tightening or loosening these straps, in connection with the curve of the posterior arms, any degree of inversion or eversion of the foot may be secured in walking. Bending the band outward and loosening the posterior strap secures eversion, and bending the bands inward and tightening the anterior strap secures inversion. The tops of the uprights where they lie in contact with the patient should be padded with felt covered with soft leather. The knee is pulled outward to the upright by a square or oblong pad of leather lined with sheepskin. This pad should cover the inner surface of the knee, and should be about four inches long by three inches wide. To the upper and lower corner and to the middle on each side are sewed leather straps running sideways, the anterior ones passing in front of the leg and the posterior behind the leg, to fasten into leather buckles, one-half of an inch wide, riveted by leather tags to three buckles on the outside of the upright—one at a point opposite the knee, and one at a point two inches above, and one two inches below the knee. There are two buckles at each level, one facing forward and the other backward. The splint is finished by being blued or japanned.

Instead of finishing the top of the upright by bending it backward,

it may be finished by being joined to a curved band lying transversely along the side of the pelvis. The upright is made as if it were to be curved upward and backward and carried to the height where the bend begins. It is then flattened and its centre drilled for the formation of a joint. A band to lie against the side of the pelvis, one inch above the level of the trochanter, is then made of sheet steel, one inch wide, No. 14 gauge, and in length reaching from just behind the anterior superior spine to the posterior superior spine of the ilium. This band is curved to fit the pelvic outline, and is padded with felt and covered with leather. At a point vertically over the trochanter is riveted to its outside a piece of steel of the same material, flattened at its lower end to make with the top of the upright an antero-posterior joint opposite the trochanter. The front and back ends of this pelvic band are furnished with buckles to carry anterior and posterior straps. The apparatus is slightly less unsightly and a little more comfortable in older children than is the kind first described. The measurements are sufficiently well defined in the description of the apparatus, the length of the upright being the distance from the lower part of the sole of the boot to a point on a level with the trochanter.

19. BOW-LEG IRONS.

Measurements for bow-leg irons are given for a child of about the age of three. They are similar in construction to the knock-knee braces just described, and certain details of construction need not be repeated. The apparatus consists of two parts: (*a*) an upright and (*b*) a foot-piece.

(*a*) The *upright* runs in the middle of the inner surface of the leg from a point opposite the inner malleolus to a point an inch or more below the origin of the adductor muscles. At this point the upright curves round the front of the thigh in a line upward and outward to a point just posterior to the trochanter. This anterior arm is convex forward, to fit the curve of the upper part of the thigh. The upright and anterior arm are made of one-half-inch cast steel, one-sixteenth of an inch thick. It is jointed below, opposite the internal malleolus, to a foot-piece similar to that described in knock-knee, except that the arm from the foot-piece to the ankle-joint runs on the inner side of the foot. The inner surface of this joint should be protected by a pad similar to that described in the knock-knee apparatus. The upper end of the upright is padded with felt and covered with leather to prevent chafing where it touches the skin; and buckles, two on each upright, one facing forward and one back, are fastened on the top of each upright. From these leather or webbing straps run, one in front of the patient and one behind the patient, to the opposite side. In the case of a single bow-leg upright these straps run to a pad of leather on

the opposite trochanter, which serves as a point of resistance for corrective pressure on the leg. In the apparatus for double bow-legs the upright at the opposite side serves to furnish resistance instead of the pad. In double bow-leg, therefore, one strap connects the uprights in front and the other behind the body. By the curve of the arms and by tightening of the anterior or posterior strap the feet and legs may be inverted or everted, as in the knock-knee braces.

(*b*) The *foot-piece* is in construction similar to that described in knock-knee.

Pressure upon the curve is made by an oblong piece of leather, similar to that described in knock-knee, furnished with two or three straps

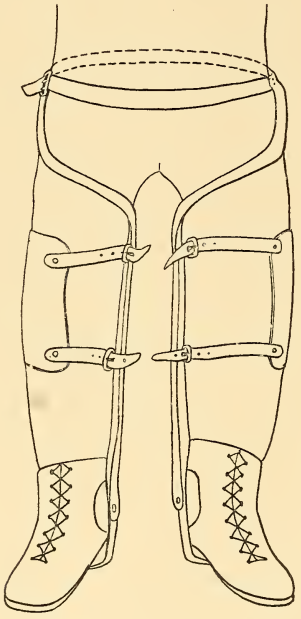


FIG. 571.—Bow-leg Irons.

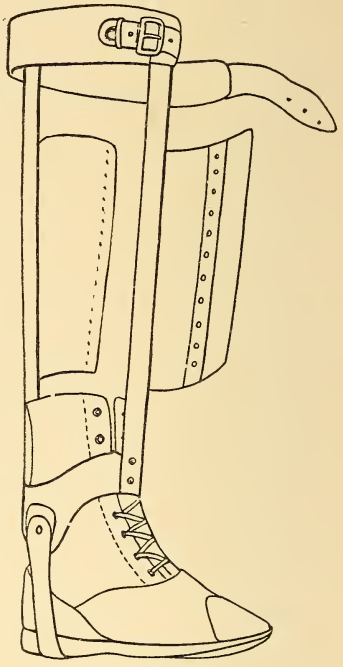


FIG. 572.—Antero-Posterior Bow-leg Brace.

at its front and back border, to pass in front of and behind the leg, and fastening into buckles upon the upright at appropriate points. This pad should embrace the entire curve of the leg.

The measurement for bow-leg irons is sufficiently described in speaking of the uprights. The length is along the inner side of the leg from the bottom or sole of the shoe to a point one inch or more below the origin of the adductor muscles. The distance is then measured from this point upward and backward to a point slightly posterior to the trochanter. The ankle-joint comes at a point opposite the inner malleolus.

When the curve involves only the lower tibia, the inner upright need not be carried above the inner condyle of the femur, where it ends in a circular steel pad fastened to its inside to press on the inner condyle of the femur, which is finished like those described in the apparatus for bow-legs and knock-knee. In this case a semicircular band is added to the apparatus just below the upper end, fastening around the leg.

20. ANTERIOR BOW-LEGS.

In addition to the apparatus described, in bow-legs with an anterior curve of the tibia two additional parts are needed. These consist of posterior semicircular strips of steel, curved to the outline of the leg, one fastened to the upright just below the knee, and the other just above the heel. These are connected at their outer ends by a strip of steel running from the outer end of one to the outer end of the other. These furnish points for the attachment of buckles, into which straps are buckled passing from an anterior leather pressure pad. In this way backward pull is exerted upon the curved portion of the leg.

21. ANTERO-POSTERIOR BOW-LEG BRACE.[1]

The object of this splint is to prevent as far as possible flexion at the knee, while pressure is exerted upon the outward bowing of the leg. It consists of: (*a*) two uprights; (*b*) a thigh band; (*c*) an ankle band; (*d*) a foot-piece.

(*a*) *The Uprights.*—These consist of pieces of sheet steel, No. 16 gauge, five-eighths of an inch wide. The anterior runs from a point one-quarter of an inch above the level of the ankle up the median line of the leg to a point a little below the level of the gluteal fold. It may be bent slightly outward at the knee if necessary. The posterior upright starts three-eighths of an inch lower than the anterior, and runs up the median line of the leg behind to the level of the top of the anterior upright.

(*b*) *The Thigh Band.*—This is a flat strip of No. 16 gauge sheet steel, seven-eighths of an inch wide, bent to fit the curve of the thigh on its inner side, and riveted to the top of each upright.

(*c*) The *ankle band* is a similar strip of steel connecting the lower ends of the uprights. It is cut somewhat curved, with the convexity downward, that its middle and lowest point may come opposite the centre of the internal malleolus. Both bands are padded on their inner surface with felt and covered with leather.

(*d*) The *foot-piece*, made of machine steel forged to fit foot, begins as a round rivet joint, so as to allow motion in flexion and extension,

[1] John Dane: Trans. Am. Orth. Assn., vol. xi., p. 151.

situated in the centre of the ankle band; it extends downward to the level of the sole of the shoe, where it is bent inward at a right angle beneath the sole and expanded into a flat plate, which is riveted to the sole. The heel of the shoe is then replaced, covering the posterior portion of this plate.

Two flaps of leather are riveted one upon each of the uprights, beginning at the bottom and reaching to just below the knee, or three-quarters up the thigh, according to the location of the bowing. These are of such a width that they overlap each other slightly around the outer side of the leg, and are finished with a row of holes or eyelets for lacing them together. A strap and buckle are riveted to the extremities of the thigh band, to pass round the outer side of the leg.

22. TEMPERED STEEL UPRIGHTS.

This form of apparatus consists of (*a*) a horizontal pelvic band, (*b*) two uprights, and (*c*) a cross-bar.

(*a*) The *horizontal pelvic band* encircles the posterior part of the pelvis from a point one inch posterior to the anterior superior spine on one side to a similar point on the other side. It is curved to fit the contour of the pelvis and should lie close against it. It is made of No. 15 gauge sheet steel, one and one-eighth inches wide. The uprights run from the posterior pelvic band along the sides of the spine to a point about on a level with the acromion process. At this point they are curved outward on the flat by an angular turn at an angle of about forty-five degrees, and run upward and outward to a point just behind the anterior border of the trapezius. In their upper part they are curved to fit the contour of the shoulders and should lie flat against the skin.

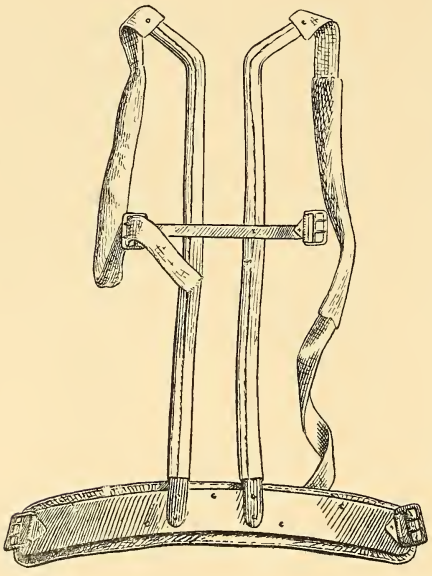


FIG. 573.—Tempered Steel Uprights.

(*b*) The *uprights* at their lower part are farther from each other than they are at the top. At the bottom their outer edges should be separated by a distance somewhat less than the distance between the two posterior superior spines. At the top they should lie over the transverse processes. They are

made of No. 16 gauge sheet steel, five-eighths of an inch wide, and should follow the outline of the back in general, but whatever correction is desired in the standing position is to be made by bending the uprights to fit the curve of the back in a corrected position rather than the curve of the back in the faulty position.

(*c*) The *cross-bar* consists of a piece of steel, which in length should be one inch less on each side than the breadth of the body at the level where it is placed. It is riveted transversely to the uprights at a point just below the posterior fold of the axilla. The projecting ends beyond the bars should not rest on the scapulæ, but if necessary should be set backward by an angular curve to clear the scapulæ. These are made of the same material as the uprights.

Buckles.—Holes are drilled for buckles at each anterior end of the pelvic band, at the top of the uprights, and at the ends of the cross-bar. Buckles are placed on the ends of the pelvic band, and the cross-bar and axillary straps are riveted to the upper ends of the uprights, one on each side. The brace is finished by being covered with leather sewed down the back throughout, or by being nickel-plated and having its anterior surface only covered with padded leather strips slightly wider than the metal parts of the brace. These are attached to the brace by loops running around the uprights, pelvic band, and the cross-bar. The brace is attached to the body at the top by means of axillary straps similar to those described in speaking of the antero-posterior support, and by means of a broad belt of sheep-skin or surcingle cloth, to each end of which webbing or leather straps are sewed, which connect the anterior ends of the pelvic band by passing around the lower part of the bottom. In cases in which there is much prominence of the abdomen, it is desirable to add an abdominal band, from four to six inches wide, running from one upright around the bottom to the other upright.

23. BRACE WITH MOVABLE SHOULDER-PIECES.

This brace is really the tempered steel brace already described, with a special cross-bar and shoulder-pieces at the top. It consists of: (*a*) a waist band; (*b*) two uprights; (*c*) a cross-piece, bearing at each end a movable L-shaped shoulder-piece.

(*a*) The *waist band* is to be made and finished as described for the tempered steel brace.

(*b*) The *uprights* likewise, except that they should end straight at the level of the first dorsal spine, and that they should be one inch apart throughout.

(*c*) The *cross-piece*—a plate of sheet steel, four to four and one-half inches long, one inch wide, and one-sixteenth of an inch thick—is riv-

eted with its front face to the top of the uprights by four iron rivets. One-quarter of an inch from each outer edge is a rivet hole for attachment of the shoulder-piece, which is riveted loose, so as to allow the shoulder-piece to move freely in one plane; the L-piece is fastened to the front face of this cross-plate, one-half of an inch from the rounded inner edge of the L-piece. The L-piece is made of the same material, one-sixteenth of an inch thick, of a uniform width of one-half of an inch. The attached arm should extend horizontally to a point on the

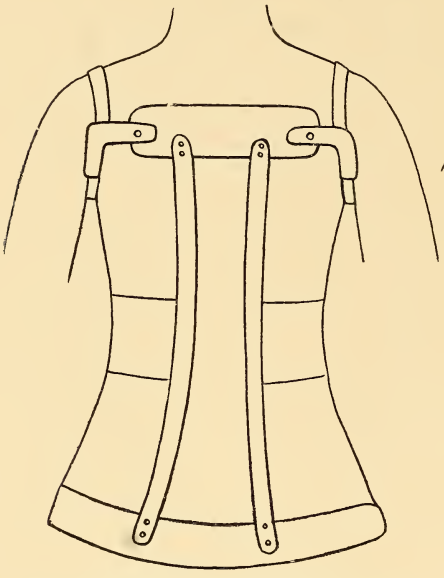


FIG. 574.—Back Brace with Movable Shoulder-pieces. (A. Thorndike.)

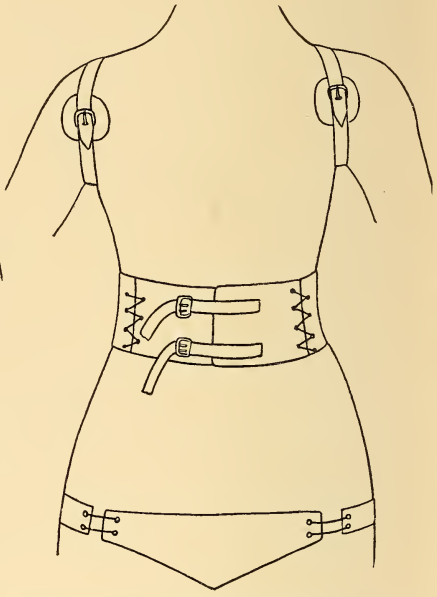


FIG. 575.—Front View of Straps and Apron in Back Brace with Movable Shoulder-pieces.

shoulder vertically above the posterior axillary fold when the arm is at the side, from which point the other arm descends at right angles three inches. A pattern of stiff paper should be made. A webbing strap, four inches long, bearing a buckle one inch from the free end, is riveted to the angle, and another eight inches long to the tip of the unattached arm of the L-piece. The webbing should be about five-eighths of an inch wide and needs no padding; for, as the shoulder-pieces and straps follow the movements of the arm, they do not rub. A piece of thick leather covers the front of the upper third of the uprights and the cross-piece, to prevent the inward movement of the posterior border of the shoulder-blades pinching the skin against the uprights. The finish should correspond to the rest of the brace.

24. TORTICOLLIS BRACE.

The brace for the retention of the head in the overcorrected position after operation for torticollis is a modification of the brace already described as the anterior head support. It consists of (*a*) a chest- and shoulder-piece which serves as a base for the rest of the apparatus, (*b*) a wire chin-piece, and (*c*) an occipital piece of steel.

(*a*) The *chest- and shoulder-piece* is not made of wire, as in the anterior support, but of flat cast steel, one-half of an inch wide, No. 8 gauge. In front it is curved in the shape of a U, and its bottom part is as wide as the horizontal distance between the middle of the clavicles running at the level of the xiphoid cartilage. From this level it is curved on the flat to run up the front of the chest vertically on each side. It is bent to rest on the shoulders, not bearing on the clavicle, and each side of the upright is then continued down the back to about the level of the tenth rib, being curved to fit the back. It is padded with felt and covered with leather stitched on the side away from the skin. Its lower posterior ends are to be provided with one buckle, into which is fastened a strap going around the chest. At a point just below the posterior fold of the axillæ are fastened two other buckles on the upright, from which pass straps along the sides of the chest below the axilla into buckles attached to the vertical part of the U-piece at an appropriate level.

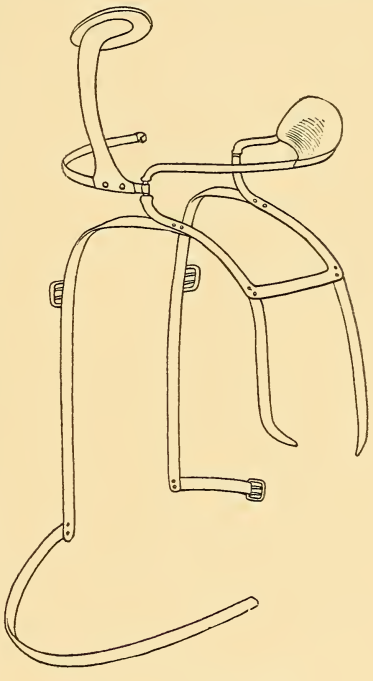


FIG. 576.—Torticollis Brace.

(*b*) The *chin-piece* is identical in construction with that described in the anterior head support, except that the hard-rubber or celluloid pad for the chin is set to one side of the middle line of the ring, and the side of the chin-piece with which it is desired to make pressure upon the chin to twist the head is carried up into a flange following the contour of the jaw, to a point half-way from the tip of the chin to the angle of the jaw. This chin-piece is put in any position which serves to hold the head with the required amount of twist.

(*c*) The *occipital piece* is made of a strip of machine steel, one-eighth of an inch thick and three-eighths of an inch wide, running horizontally behind the head and bent around the wire upright on one

side, forming a hinge, and secured to the opposite upright by a hook catch made by bending over its end. From one side of this upright there runs up a steel stem of wire, three-eighths of an inch in diameter, flattened at its lower end and riveted to the occipital piece. This should rise to the level of the parietal eminence of the head. Riveted to this at its top, which should be flattened, is a pad of steel or phosphor bronze, oval in shape, approximately two inches in height by three inches in breadth, which is shaped to fit the contour of the head and tips the head to the desired side. This pad is padded by felt and covered with leather.

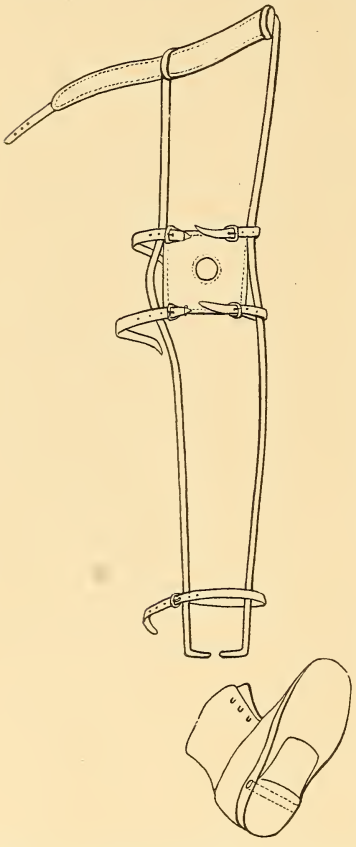


FIG. 577.—Caliper Apparatus for Anterior Poliomyelitis.

25. CALIPER APPARATUS FOR ANTERIOR POLIOMYELITIS.

A modification of the Thomas caliper splint is the simplest apparatus for cases of paralysis of the leg, in which the power of the extensor muscles of the thigh is not sufficient to hold the leg straight in standing or walking. It is also to be used in cases of spastic paralysis in which it is desired to hold the knee extended. The apparatus consists of (*a*) two uprights and (*b*) a posterior thigh band.

(*a*) *The Upright.*—The inside of the upright runs from the bottom of the sole of the shoe to a point at least one inch below the perineum. The outer upright runs from the sole of the boot to a point at least one and one-half inches below the top of the great trochanter. A line connecting these two points should be at least one inch below the fold of the buttock. At the lower end of the uprights, where they are on a level with the bottom of the sole of the shoe, each upright is turned inward at a right angle for a distance of at least one inch, to fasten into a hole in the bottom of the heel of the shoe, as described in the Thomas caliper splint. The uprights may be curved to follow the inside and the outside of the leg, but are stronger if they are left straight. They are slightly less noticeable if they are curved to follow the outline of the leg.

(*b*) The *posterior thigh band* is made of a strip of sheet steel, one

and one-quarter inches wide and one-sixteenth of an inch thick, encircling the posterior half of the upper part of the thigh and shaped to fit it. It is soldered to the upper parts of the uprights and made straight across or slanting downward from without inward. It should be padded with felt and covered with leather. The knee is held in extension by an oblong piece of leather, four inches long and three and one-half inches wide, made of sole leather and faced with sheep-skin. In its centre is cut a hole, the size of the patella, in order to avoid pressure on that bone. From the top and bottom on each side, stitched to the anterior surface of the knee-cap, a strap six inches long and one-half of an inch wide runs sideways, passing around the upright and back to buckle at the knee-cap at the origin of the strap. To prevent the knee-cap from slipping down, it is desirable to solder on the outside of the upright, where the strap passes round it, a small wire loop, through which pass the two top straps. In cases in which very much pressure comes upon the knee-cap, it may be modified by anterior bands of leather running from one upright to the other, at the lower third of the thigh and the upper third of the calf. These bands are made in the same way and of the same material as the knee-cap.

25. SUPPORTING LEG BRACE FOR ANTERIOR POLIOMYELITIS.

In infantile paralysis involving the leg and foot, it is frequently necessary that a supporting brace to prevent flexion or hyperextension of the knee should extend up from the foot-piece. This may be jointed at the knee to enable the patient to sit down with greater comfort. This apparatus consists, in addition to the foot-piece, of (*a*) two uprights, (*b*) two or three posterior calf bands, and is used only in connection with one of the foot-pieces described in speaking of the various deformities of the foot caused by infantile paralysis, in connection with one of which it should always be used. Another form of the apparatus, shown in the figure, has only one upright.

(*a*) The outside *upright* runs from the point opposite the outer malleolus to a point one and one-half inches or more below the trochanter. It should be made of flat machine steel, five-eighths of an inch wide, one-quarter of an inch thick, and should be curved to follow the outline of the leg, a space being left so that the upright will not touch the outer malleolus or the outer surface of the knee-joint. For the rest of its course it should be closely applied to the leg. The inner upright is made in the same way, running from the internal malleolus to a point one inch or more below the perineum. A line connecting the two uprights, passing round the back of the thigh, should be oblique and lie at least one inch below the fold of the buttock. Both uprights should

be jointed at the knee by antero-posterior joints moving in the same plane, and the outer joint should be furnished with a drop or spring catch, to be loosened when the patient sits down. The upper thigh band should be three inches wide at its outer end and one and three-quarters inches wide at its inner end, and should form the posterior half of a circle, being shaped to fit the back of the thigh. It is riveted to the inside of the top of the uprights, and is made of sheet steel, No. 15 gauge.

(*b*) There should be *posterior bands* at the lower third of the thigh and the upper third of the calf, one inch wide and made of the same

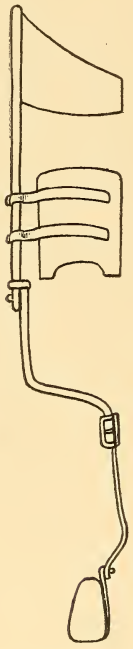


FIG. 578.—Supporting Leg Brace for Anterior Poliomyelitis, with One Upright.

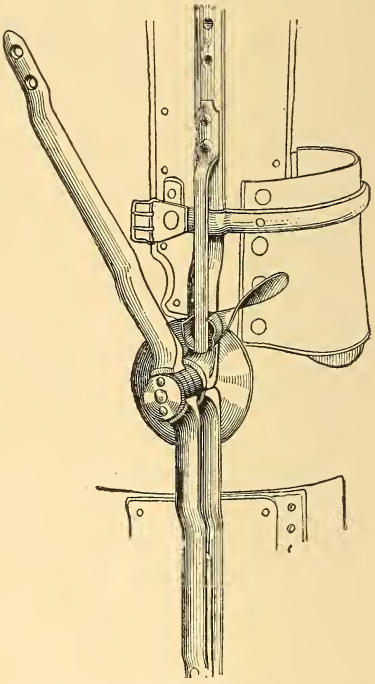


FIG. 579.—Mechanism for Locking Knee-joint. (H. L. Taylor.)

steel, curved to fit the posterior surface of the thigh and calf, riveted to the uprights. Below the ankle-joint the apparatus is the same as that described in speaking of the various forms of talipes. The measurements of the apparatus have been indicated in describing the different parts of it. The apparatus may or may not require a knee-cap, and the thigh and leg are supported by cuffs of leather running from the top of the splint to just above the knee and from the tubercle of the tibia to a point two inches above the malleolus. These straps are split in the middle line in front, and fit the calf and thigh closely be-

hind, and are laced by means of hooks or eyelets placed at one-half-inch intervals near the front border of the cuff.

In case the foot-piece has only one upright, it is connected with the

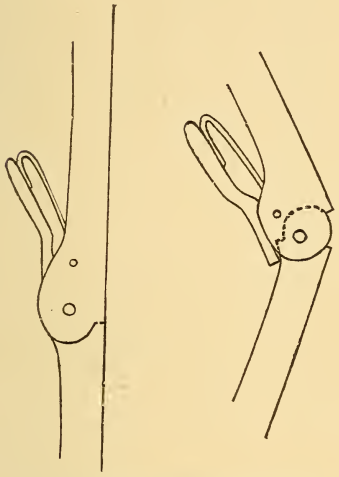


FIG. 580.—Self-locking Spring Catch.

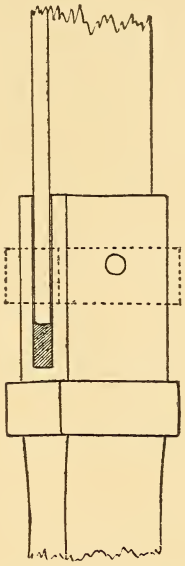


FIG. 581.—Drop Catch.

leg part of the apparatus as follows: The upright running from the foot-piece, whether on the outside or inside, is made heavier than the

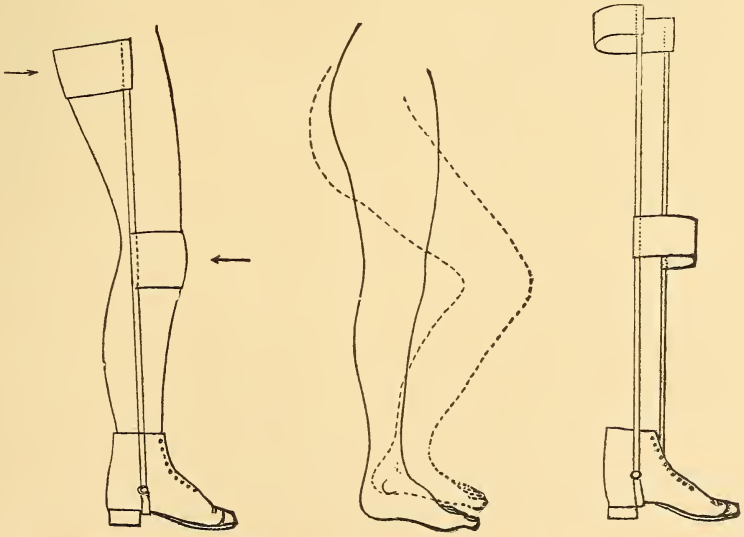


FIG. 582.—Supporting Apparatus in Paralysis of Anterior Thigh Muscles.

other. At the lower third of the calf, the upright which is not connected with the foot-piece is turned backward at a right angle, being curved on the flat, and runs around the back of the calf, being curved with its convexity backward, and is riveted at its free end to the outer side of the long upright which connects with the foot-piece. It should run transversely across and should be closely applied to the back of the calf. Above this point the apparatus is the same as that described above, except that the upright connecting with the foot-piece must necessarily be somewhat heavier than the other.

The apparatus thus consists of a foot-piece; an upright connecting with it either on the outside or the inside, running the whole length of the leg; and another upright running from the lower third of the calf the whole length of the leg, or one upright may be used passing behind the calf as described. Either form of apparatus is finished by being nickel-plated, blued, or japanned.

The form of foot-piece required to complete the leg apparatus is determined by the kind of deformity existing in the foot.

27. EQUINO-VARUS SPLINT.

This apparatus consists of (*a*) a sole plate, (*b*) an upright, and (*c*) a calf band.

(*a*) The *sole plate* consists of a *bottom part* and *side flanges*. The sole plate is made of sheet steel, No. 16 gauge. The bottom part is shaped to fit the weight-bearing portion of the normal sole. The plate is cut so that flanges can be turned up to furnish pressure on the inner side of the end of the os calcis and the head of the first metatarsal and its adjacent phalanx. The intervening space on the inner side of the plate is cut out to lighten the brace.

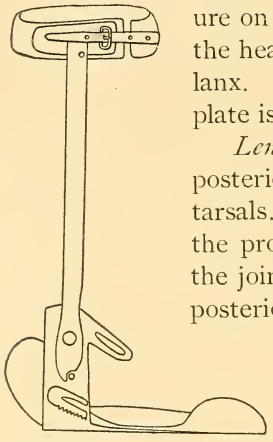


FIG. 583.—Splint for Equino-varus.

Length.—The sole plate should extend from the posterior border of the heel to the heads of the metatarsals. The forward side flange should extend from the proximal end of the head of the first metatarsal to the joint between the phalanges of the great toe. The posterior side flange presses on the inner side of the os calcis, on the portion posterior to a line from the internal malleolus extending downward. The plate is in front as wide as the breadth of the ball of the foot, and behind as the width of the os calcis. The shape of the plate can be indicated by cutting it out of cardboard and fitting it to the foot.

(*b*) The *upright* extends up the side of the leg and consists of two parts, a lower and an upper, five-eighths of an inch wide and one-quar-

ter of an inch thick. The lower part is of steel plate, No. 8 gauge, forged at the bottom to fit the posterior part of the sole plate, to which

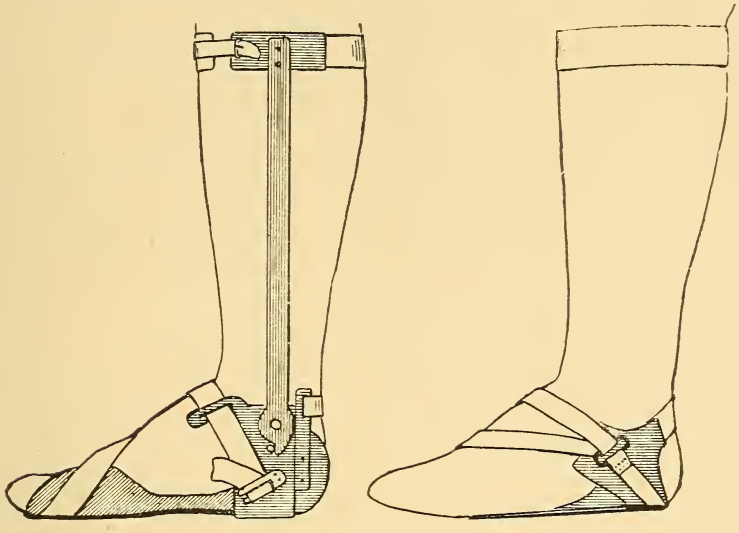


FIG. 584.—Inner and Outer Views.

it is fastened by three steel rivets. It is bent at right angles on the inner edge of the sole plate, and extends on the line of the internal malleolus as high as one-half of an inch above the malleolus.

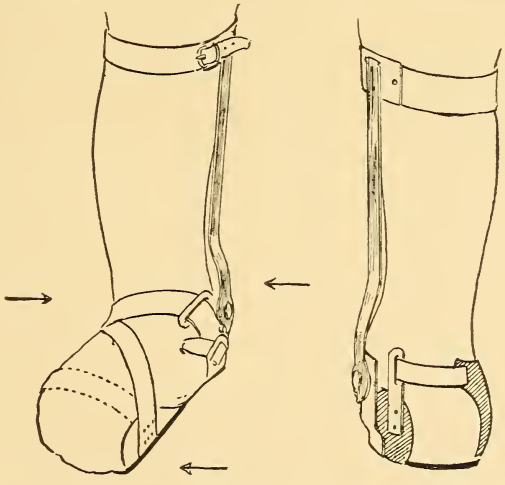


FIG. 585.—Club-foot Shoe, from Front and Back. Arrows show direction of force exerted by straps.

The upper part is a flat steel bar, one-half to three-quarters of an inch wide and No. 10 gauge, and extends from just below the malleolus to the level of the insertion of the inner hamstring.

In order to prevent the dropping of the foot into the position of equinus, the joint opposite the inner malleolus is made as follows: The two parts of the upright which join at this place are flattened into circular discs, one inch in diameter, and the centre is pierced with a hole for a steel rivet, making an antero-posterior joint. In order to prevent the dropping of the foot, the front lower edge of the flattened disc on the lower end of the upright is ground away for a distance of one-quarter of an inch, beginning at the middle of its lower part. This

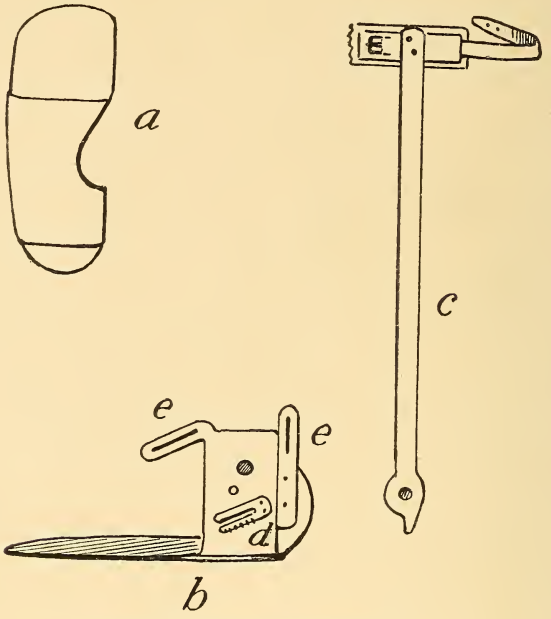


FIG. 586.—Details of Construction.

leaves a sharp projecting lip at the middle of its lower surface, which strikes against a pin inserted into the other disc forming the joint, and checks plantar flexion of the foot, although allowing dorsal flexion.

The upright is bent in such a way as not to strike the internal malleolus when the foot is placed in a position of valgus.

(*c*) The *calf band* consists of a leather strap going around the leg, which starts from and is buckled to a small steel plate at the top of the upright.

Leather and Straps.—The sole plate is covered by thin calfskin, felt being placed between the leather and the side flanges of the foot-piece. Strong webbing straps are furnished to secure the foot in the sole plate and to press the head of the os calcis, the astragalus, and the external malleolus to the inner side. These straps are fastened on the outer side to a triangular piece of leather riveted to the sole plate, and extend

on the outer side so as to furnish pressure on the outer side of the os calcis. The straps pass around the ankle and are secured to catches or buckles placed on the lower and broader portion of the upright.

The front strap passes through a steel guard attached to the upright at the level of the ankle, which protects the strap from chafing the upright.

A strap to keep the heel down is sometimes needed. It is riveted to the sole plate, passes on both sides of the ankle, and is secured by a buckle in front of the ankle. Felt is needed to prevent the skin from being chafed. A strap runs across the front of the foot to keep the foot close to the plate.

28. APPARATUS FOR TALIPES EQUINUS.

For uncomplicated talipes equinus two types of apparatus are in use. This apparatus consists of (*a*) one or two uprights, (*b*) a foot-piece, and (*c*) a posterior calf band.

(*a*) The *uprights* are one or two in number. If two are used, one is outside and one inside the leg, and these run from the bottom of the ankle-joint outside of the boot to a point one inch below the tubercle of the tibia, where they are joined by a posterior calf band. They are made of cast steel, No. 10 gauge, and should be shaped to follow the outline of the leg, clearing the malleolus. At the bottom the upright proper ends at the ankle-joint, the part below the ankle-joint being considered the foot-piece. The lower end of the upright is flattened into a circular disc, five-eighths of an inch in diameter, and its centre is drilled for a hole for the connecting spindle of the joint. Both uprights are finished in the same way, the level of the joint being just below the prominent part of the internal malleolus. If one upright is used, it should be made of sheet steel, No. 10 gauge, and ends in a posterior calf band fastened around the leg by a strap and buckle.

(*b*) The *foot-piece* consists of a sole plate and two pieces running up to join the uprights. The sole plate consists of a piece of sheet steel, No. 17 gauge, with a straight posterior edge, which runs far enough back to pass between the heel of the boot and the sole of the shoe, being covered by the heel of the boot. Its anterior end then runs along the under side of the shank of the boot for a distance of one-half of an inch, being covered on its anterior part by an extra piece of sole leather, tapped on to the bottom of the sole of the boot covering in the front of the foot-piece. The steel tongue which runs forward should be narrower than the shank of the boot and run well forward to the metatarso-phalangeal joint. It is riveted to the sole of the shoe through holes drilled in it in three or four places. The side arms of the foot-piece should be at least one-quarter of an inch wider than the foot

where they pass up at the edge of the sole. They should be turned up at a right angle to join the lower ends of the upright, and should be flattened and drilled as described to form a joint with the lower ends of the upright.

Joint.—In order to prevent the plantar flexion of the foot, which is the deformity to be corrected in talipes equinus, the joint must be constructed in the same way as in the splint for equino-varus to prevent dropping of the foot.

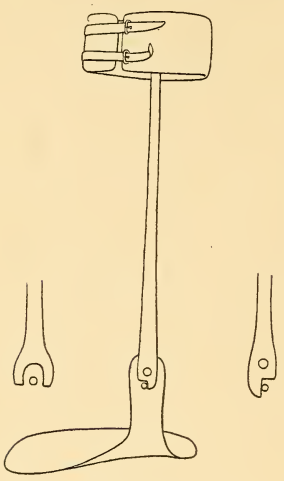


FIG. 587.—Apparatus for Talipes Equinus, with Stop Catch. On the right of the picture is a detail drawing of the stop for talipes calcaneus, on the left a catch allowing slight motion.

(*c*) The *posterior calf band* at the top of the upright is made of No. 17 gauge sheet steel, riveted to the inner surface of the upright or uprights at the top, and curved to fit the calf of the leg. This is padded with felt, covered with leather, and provided with a strap and buckle to pass round the anterior part of the leg.

The apparatus may be finished by being nickel-plated, blued, or japanned.

Another type of apparatus may be used for uncomplicated talipes equinus, which is less unsightly, as it goes inside the boot. It consists of (*a*) a foot-piece, (*b*) two uprights, (*c*) a posterior calf band, and in construction it follows the lines indicated in speaking of the fixation splint for ankle-joint disease, except that it is jointed opposite the malleolus and that no lacing over the foot is required. It is not attached to the boot.

(*a*) The *foot plate* is covered with a smooth piece of thick leather, riveted on, and is worn inside the boot. The joint at the ankle is of the same kind as that described in the apparatus just mentioned for talipes equinus with a right-angle stop-catch. The apparatus in other respects presents no difference.

APPARATUS FOR TALIPES EQUINUS COMPLICATED WITH VARUS OR VALGUS.

The apparatus for equino-varus has already been described. When talipes equinus exists with any degree of valgus, the shoe described in speaking of talipes valgus is the most useful, and the only modification necessary in it is the addition of a right-angle stop-catch to prevent plantar flexion of the foot. This is identical in construction with the joint described in speaking of the apparatus for equinus.

29. APPARATUS FOR TALIPES CALCANEUS.

For uncomplicated cases of talipes calcaneus the forms of apparatus described for talipes equinus are to be used, with a simple modification.[1] This modification consists in reversing the stop-joint at the ankle, so that it prevents dorsal flexion but allows plantar flexion to the foot. This is done by cutting away the posterior half of the lower surface of the disc forming the lower end of the upright, and putting a pin in the part of the foot-piece at such a place that it will strike against the projecting lip left at the anterior half of the lower border of the foot-piece. It is only necessary to do this over the outer malleolus, and the inner joint may be left free. The construction in other respects is the same as that described in speaking of the joint for talipes equinus. If talipes calcaneus exists with either varus or valgus, the varus or valgus shoe with a steel sole plate should be provided with an appropriate stop-joint.

30. APPARATUS FOR TALIPES VARUS.

For cases of a severe grade the splint described for the treatment of equino-varus is to be used, without the right-angle stop-catch at the ankle-joint.

For cases of lighter grade the reverse of the apparatus described for talipes valgus would be of use. In this apparatus the upright and foot-piece should run up the inner side of the leg. The joint is opposite the inner malleolus, and the T-strap is fastened to the outer border of the shank of the boot and passes around the external malleolus. This apparatus is, of course, much less efficient than the one just described.

31. APPARATUS FOR TALIPES VALGUS.

The deformity in talipes valgus is most easily controlled by an apparatus following the same general lines in its construction as that described for equino-varus, except that, of course, the upright runs on the outside of the leg and the pull of the apparatus is reversed. This apparatus consists of (*a*) an upright, (*b*) a sole plate, and (*c*) a calf band.

(*a*) The *upright* is made of steel similar to that described in speaking of the shoe of equino-varus, and runs from a point one inch below the tubercle of the tibia, where it terminates in a band forming about one-third of a circle and curved to fit the outer contour of the leg, avoiding the external malleolus.

(*b*) The *sole plate* consists of a flat plate of No. 16 gauge sheet

[1] See Fig. 587.

steel, turned up at a right angle along its outer border for a distance of three-quarters of an inch to follow the outer border of the foot. This turned-up edge should reach from behind the head of the fifth metatarsal to a point one-half of an inch in front of the posterior part of the os calcis. It is often necessary to bend it out or cut it away over the base of the fifth metatarsal. The length of the bottom of the plate is from just behind the cleft between the toes and the ball

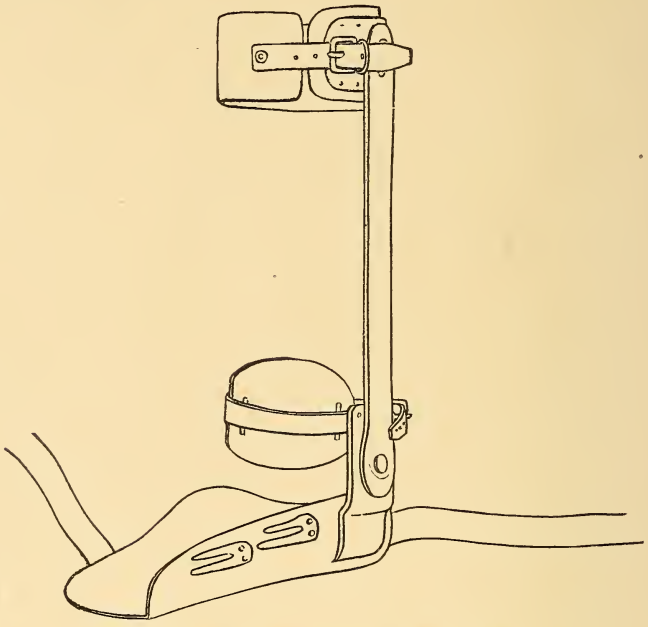


FIG. 588.—Apparatus for Talipes Valgus.

of the foot to a point one-half of an inch in front of the posterior end of the os calcis. Its width is one-quarter to one-half of an inch less than the breadth of the sole of the foot. It is generally desirable to arch the inner surface of the plate somewhat to follow the curve of the arch of the foot. This adds to the efficiency of the apparatus by helping to antagonize the valgus by preventing dropping of the arch and rolling of the foot on to its inner side.

This plate is connected with the upright by means of a right-angled piece of machine steel, No. 10 gauge, three-quarters of an inch wide, which runs across its under surface and is riveted to the sole plate. On the outer border of the sole plate it turns up at a right angle and runs to a point opposite the external malleolus, where its upper end is flattened into a disc, five-eighths of an inch in diameter, the centre of which is drilled by a hole, three-eighths of an inch in diameter, for the insertion of a spindle which connects it with the lower end of the up-

right. In the case of a pure valgus deformity there is no need of a stop-catch at the joint. If the valgus is associated with an equinus deformity a stop-catch is required, of the kind described in speaking of the apparatus for equinus. If it is associated with a calcaneus deformity the reverse stop should be used, which is described in speaking of calcaneus.

(*c*) The *band* is provided with a strap and a buckle to encircle the leg, and is padded with felt and covered with leather. It is riveted to the inner surface of the top of the upright.

The foot is fastened to the sole plate by means of two or three webbing straps, which are riveted to the inner border of the sole plate, pass over the dorsum of the foot and the turned-up outer edge of the plate, to fasten into clasps described in the shoe for equino-varus. These are fastened on to the outer surface of the turned-up edge of the foot plate. One of these straps will be required at the front of the foot and one toward the posterior part of the foot plate.

The essential part of the apparatus is a T-strap, which passes around the inner malleolus, holding it outward. This strap, which should be made of sole leather, is fastened at its base to the upper surface of the inner border of the foot plate directly below the internal malleolus. It passes upward and broadens one inch below the malleolus to form two straps, which run at right angles to the vertical axis of the leg. The height of this strap should be the distance from the foot plate to a point one inch or less above the lower border of the internal malleolus. The horizontal parts of the T-strap then pass outward at the level of the malleolus around the upright and below the malleolus. One strap is furnished with a leather buckle, five-eighths of an inch wide, into which the other end of the strap fastens. It is desirable that this buckle, when fastened in place, should lie against the outer side of the upright, so that it does not lie against the soft parts.

The measurements of the splint are self-evident. A cardboard pattern of the sole plate should be furnished and the length given from the bottom of the sole plate to a point one inch below the tubercle of the tibia. The height of the external malleolus from the sole plate is given. The posterior band is one-third of the circumference of the calf at that level.

A simpler and lighter apparatus may be used for uncomplicated cases of talipes valgus. It consists of (*a*) an upright, (*b*) a foot-piece, and (*c*) a calf band.

(*a*) The *upright* extends on the outside of the leg from the external malleolus to a point one inch below the tubercle of the tibia. It is made of machine steel and is five-eighths of an inch wide. It is fastened to the top of the foot-piece at the ankle-joint by means of a free joint similar to that described in speaking of the apparatus for knock-knee.

(*b*) The *foot-piece* is similar to that described in the apparatus for knock-knee, and is fastened to the bottom of the shoe and runs up on the outside of the foot to join the upright at the outer malleolus.

(*c*) The *calf band* is like that described in the other apparatus for valgus. The apparatus is entirely outside of the shoe and is put on and off with the shoe. The T-strap described in speaking of the other apparatus for valgus is fastened to the bottom of the inside of the shank of the boot at a point directly below the internal malleolus. It runs up and buckles around the upright of the splint in a manner similar to that described in speaking of the other apparatus for valgus, except that, of course, it is outside of the boot. If any element of equinus or calcaneus exists, an appropriate stop-joint is put in at the ankle, as has been described in speaking of these affections.

32. FLAT-FOOT PLATES.

The details of the manufacture of flat-foot plates have been so fully described in the chapter on flat-foot that they will not be discussed here (Chapter XX.).

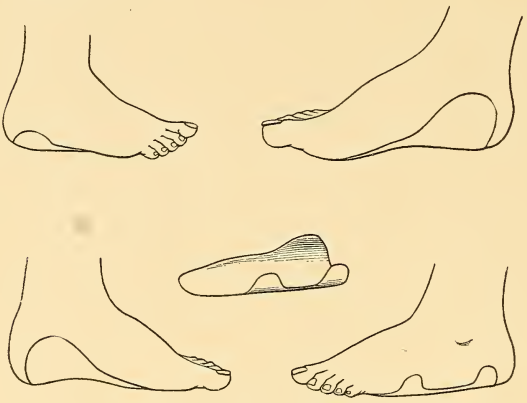


FIG. 589. —Flat-foot Plates.

FIG. 590. — Flat-foot Plate Raised in Front to Support Anterior Arch.

FIG. 591.—Flat-foot Plate. Right foot.

33. TOE-POST.

In cases of hallux valgus it is frequently desirable to introduce a vertical partition in the line of the length of the foot between the first and second toes, in order to hold the great toe in a correct position. This toe-post, as it is called, may be held in place in one of two ways

It may be passed up through an inner sole fitting accurately in the boot, in which case it may be moved from one pair of boots to another; or it may be passed up through the sole of the boot from the under surface, in which case it could not, of course, be changed from boot to boot. The description in this connection applies to the case of an adult. The toe-post at its posterior border is situated one-quarter of an inch from the cleft between the first and second toes. At its anterior border it should not reach within one-quarter of an inch of the front end of the great toe. In height it should not reach above the top surface of the great toe with the foot resting on the ground. It is made of sheet steel of the required width and one-sixteenth of an inch in thickness. It is cut in a strip three and one-half inches long and of the width indicated. This strip is then folded in its middle, as one would double a piece of paper by creasing. The thickness of the toe from the top to the bottom is then measured, and the thickness of the sole is added to this and marked on the folded piece of steel. At this point a sharp right-angular bend is made on each side, the bent ends of the steel forming a continuous straight line, with which the double upright forms a right angle. The ends of the steel are then cut off to the desired length. A tracing of the foot is then made on a piece of paper and the desired position of the toe-post is indicated on the tracing. A vertical slit is then made in the boot at this point, and the vertical part of the toe-post is passed up through it to protrude into the boot. The toe-post is more comfortable if covered with a thin piece of leather before being introduced into the shoe. The ends of the steel which are against the bottom of the sole are then fastened in place, and an extra tap is put on the bottom of the sole to cover in the piece of steel which has been fastened to the bottom. Inside of the boot a stall is thus provided for the great toe. It is, of course, necessary in the use of the toe-post that a stocking should be worn with a partition between the first and the second toe. The measurement as here given applies to the use of the toe-post when permanently fastened to the shoe. When it is to be used in an inner sole, the height of the vertical part is the measurement of the thickness of the toe. It is then passed through a slit in an inner sole and the bottom pieces of the toe-post are fastened to the sole by stitching. An inner sole should be made of sole leather with the polished side up, cut accurately to fit the sole of the boot.

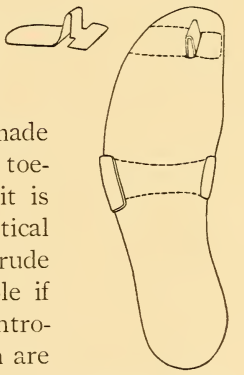


FIG. 592. — Toe-post Inserted in Sole.

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